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BIM Application Research Based on the Main Entrance and Garden Area Project of Shanghai Disneyland

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***Abstract*—**Based on the main entrance and garden area (ME&G) project of Shanghai Disneyland, this paper introduces the application of BIM technology in this kind of low-rise comprehensive building with complex facade system, electromechanical system and decoration system. BIM technology is applied to the whole process of design, construction and completion of the whole project. With the construction of BIM application framework of the whole project, the key points of BIM modeling methods of different systems and the integration and coordination of BIM models are elaborated in detail. The specific application methods of BIM technology in similar complex low-rise building projects are sorted out. Finally, the paper summarizes the benefits of BIM technology application, and puts forward some suggestions for BIM management mode and practical application of similar projects in the future.

***Keywords*—**BIM, complex low-rise building, BIM modeling, model integration and coordination, 3D scanning.

I. Introduction

BIM technology is a kind of data-based tool applied in engineering design, construction and management. With the integration of building data and information model, it can be shared and transmitted in the whole life cycle of project planning, operation and maintenance. Thus the engineers can correctly understand and effectively respond to various building information. It can also provide the basis for the design team and the other participants including the construction and operation teams to work together, which plays an important role in improving production efficiency, saving costs and shortening construction period. The concept of BIM was first proposed in the 1970s, as in Eastman et al. [1], but it was not until 2002 that Jerry Laiserin [2] formally brought BIM into people's vision. In recent years, a large number of scholars and organizations have improved the definition of BIM. At present, the definition of National Building Information Modeling Standard [3] is more complete, which is "BIM is a digital representation of the physical and functional characteristics of a facility (construction project); BIM is a shared knowledge resource, a process of sharing information about the facility and providing a reliable basis for all decisions in the whole life cycle of the facility from concept to demolition; at different stages of the facility, different stakeholders support and reflect the collaborative work of their respective responsibilities by inserting, extracting, updating and modifying information in the BIM".

A building information model includes the geometry, spatial relationship, geographic information, quantity and property of building elements, cost estimation, material inventory, project schedule and other information. This model can be used to demonstrate the whole life cycle of buildings [4]. Thus, the quantity and shared properties of materials can be easily extracted, and the scope of work can be easily isolated and defined. Systems, components, and sequences can be displayed at a relative scale throughout a facility or group of facilities. Construction documents, such as drawings, procurement details, submission processes, and other specifications can easily be correlated [5]. The emergence of BIM has largely achieved the goal of reducing project cost and delivery time and improving productivity and quality [6].

BIM was first developed from the United States. With the process of globalization, BIM has been developed and applied to a certain level in many countries around the world. In China, BIM started late, but has developed rapidly in recent years. On the standard aspect, Tsinghua University proposed the CBIMS [7] (Chinese Building Information Modeling Standard) in 2010 by referring to NBIMS after combining it with research. On the government aspect, the Ministry of Housing and Urban-Rural Development issued a series of policy documents related to informatization of the construction industry in May 2011 and January 2012, respectively, which promoted the development of BIM in the engineering construction industry. On the scientific research aspect, many universities in China, such as Tsinghua University, Shanghai Jiaotong University and Tongji University, have launched a series of BIM-related scientific research and talent cultivation, laying a theoretical and talent foundation for the development of BIM. On the enterprise aspect, in recent years, many designing institutes, construction units, consulting units and real estate companies have begun to attempt and explore BIM, and have launched BIM applications in the whole life cycle in some large projects, such as Shanghai center [8] and Shanghai Disneyland [9]. All of the above points indicate that BIM application in China has entered a period of rapid development.

This paper will introduce the application of BIM in this complex low-rise building based on the main entrance and

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garden (ME&G) area project of Shanghai Disneyland. With the construction of BIM application framework of the whole project, the key points of BIM modeling methods of different systems and the integration and coordination of BIM models are elaborated in detail. The specific application methods of BIM technology in similar complex low-rise building projects are sorted out. Finally, the paper summarizes the benefits of BIM technology application, and puts forward some suggestions for BIM management mode and practical application of similar projects in the future.

II. Application of BIM Technology in Shanghai Disneyland ME&G Project

A. Construction Index, Construction Requirements and Project Characteristics of Shanghai Disneyland ME&G Project

Fig. 1 ME&G project of Shanghai Disneyland

Shanghai International Tourism Resort (Shanghai Disneyland) project was divided into three phases. The main entrance and garden area project (ME&G project) belongs to the first phase. The total construction area is 16264 m^2, including 21 single buildings and 83250 m^2 landscape, shown as in Fig. 1. It is a project with many professional integrated systems, involving architecture, concrete structure, steel structure, water supply and drainage, fire protection, kitchen, ventilation and air conditioning, decoration, landscape, etc. Therefore, there are many works in the construction deepening design stage, including the theme plastering, curtain wall design, interior decoration design, waterproof design and other detailed designs of the architectural decoration specialty, primary steel structure design, secondary steel structure design and exposed decorative steel structure design of the structural specialty, water supply and drainage, heating, electrical, ventilation and air conditioning, gas design, building intelligence, elevator, power, fire engineering design and kitchen special design of the mechanical and electrical specialty. It is difficult to manage and coordinate.

B. BIM Application of Shanghai Disneyland ME&G Project

Based on the complexity of the project, the limitations of traditional SU software and 2D design methods are increasingly prominent, resulting in slow progress of the project. Therefore, Shanghai Disney requires all areas to adopt BIM technology and create a BIM model for every single building, which is combined with the site model and effectively solves the problem of this project by using BIM technology. Disney BIM project adopts Trello platform as the problem coordination platform, and adopts the way of BIG ROOM for meeting coordination every week.

Due to the high-quality requirements of the project, the requirements for architectural design, construction and installation are strict, while the construction period is tight and the task is heavy. Therefore, BIM collaborative design is adopted in this project. Compared with the linear workflow of traditional design, BIM collaborative design can manage different professional participants as a whole. Participants mentioned above complete their own in-depth models under the unified standard, and then integrate each part into a complete BIM model of this project. This process continuously deepens the accuracy of the model. In view of all kinds of collision and design problems in the integrated model, after discussion and coordination, the model is split again and returned to their respective specialties for model revision and problem solving. In this way, the BIM model and in-depth processing drawings that have been completely verified and reviewed can be handed over to the construction unit and the operation and maintenance team after the completion of the project.

III. System Composition and Modeling Requirements of Complex Low-Rise Buildings

A. Composition System of Single Building

The ME&G project of Shanghai Disneyland is a typical complex low-rise building with a complex specialty integration system, involving architecture, concrete structure, steel structure, water supply and drainage, fire protection, kitchen, ventilation and air conditioning, decoration, landscape, etc. BIM modeling of this project divides all specialties involved into three parts, which are created by different companies, including BIM model of civil engineering based on architecture and concrete structure, BIM model based on steel structure and light steel structure, and MEP model based on HVAC, water supply and drainage, and electrical.

B. Project Modeling and Model Integration Requirements

As mentioned before, different specialties of the project are modeled by different participants. According to the needs of different specialties, different modeling software is used for

each specialty, and then the integration and coordination are carried out. This project takes Revit as the modeling core, and Tekla completes the in-depth design and processing of steel structure and light steel structure, AutoCAD MEP, MEP Fabrication, Tfas, etc. completes the deepening of MEP specialty, and finally integrates and browses all models of these specialties in NavisWorks. All specialties need to complete the model creation under the unified standard. Through the integration of the model, problems of collision and design are found, the design is coordinated, and then the model is split again, distributed to all specialties for model revision and deepening.

C. LOD Requirements in different Phases of the Project

A project has different LOD (Level of Details or Level of Development) requirements for the BIM model in different stages. LOD can be divided into five levels: L100 (conceptual depth), L200 (approximate depth), L300 (accurate depth), L400 (machining depth) and L500 (completion depth), shown as Fig. 2 [10]. Generally, the LOD of the first version of design model only needs to reach L300 or L350. This model is used to check the consistency of drawings and BIM model of different specialties, and revise the existing problems. In practical application, The L350 BIM model still cannot meet the construction requirements, which needs to be further revised and deepened in combination with the actual situation of the construction site and design changes. The completion depth of L500 will be reached in the completion phase by constantly deepening the model.

IV. BIM Modeling Method for Different Systems of Single Building

Taking the ME&G project of Shanghai Disneyland as an example, this paper introduces the BIM civil modeling method of this kind of complex low-rise building. From the perspective of BIM civil modeling, the construction system of the project mainly includes wall system, roof system, door and window system, structural system, etc.

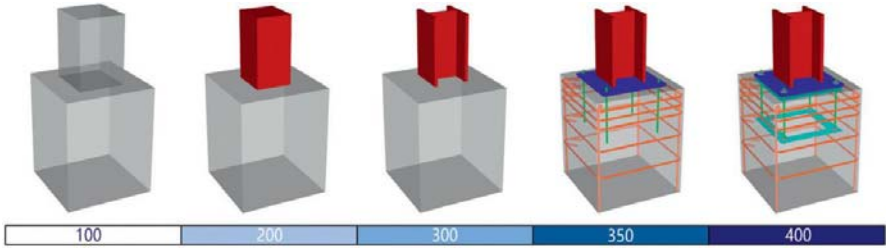


Fig. 2 LOD with different level

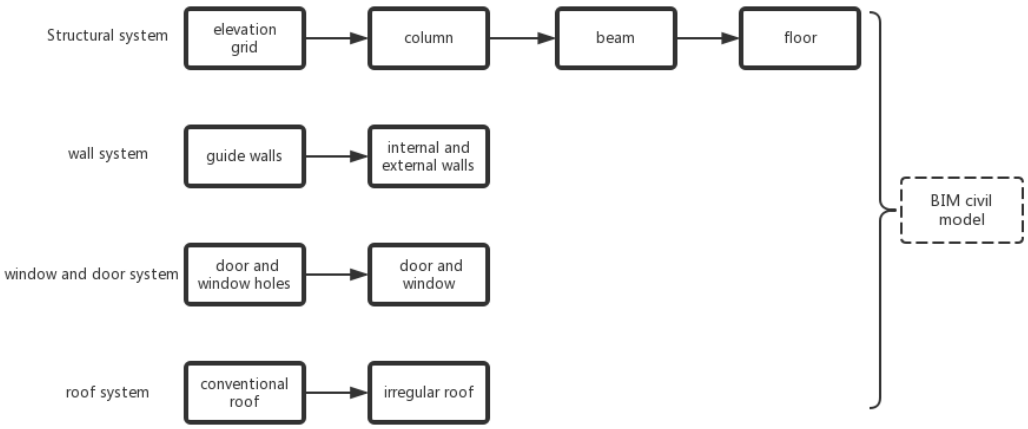


Fig. 3 BIM modeling

A. Modeling Steps and Key Points of Wall System in Revit Software

The internal and external walls of the single unit of the project adopt the light gauge steel form, concrete form and mixed form. The main steps of wall modeling are: first, query and determine the type tag of different walls, draw guide walls, internal and external walls and other special walls in turn according to the drawings, and then check and modify the model with other participants of different specialties. In the process of modeling, it is important to pay attention to the handling of the opening of the wall, the connection with other building parts and the collision with other specialties.

B. Modeling Steps and Key Points of Roof System in Revit Software

The roof shapes of different single units in this project are different. According to its characteristics, it can be divided into two types: conventional roof and irregular roof. The steps of roof modeling are as follows: firstly, refer to the design description of drawings and clarify the detailed design information of different roofs. Secondly, according to whether

these design parameters are common features, set corresponding type property and instance property parameters for roof family. Finally, according to the drawing, select the appropriate command to draw the roof. It should be noted that for some irregular roofs, you need to draw them by creating internal models or masses.

C. Modeling Steps and Key Points of Door and Window System in Revit Software

Because every single building of Disney project has a theme and the corresponding door and window styles are different, the door and window families among different single buildings cannot be shared basically. The main steps of door and window modeling are as follows: firstly, determine the components of the door and window family according to the door and window Part List, and then draw them by type in turn. In this project, considering that the size of the traditional wall-based door and window family cannot be directly reflected in the three-dimensional model, the problem can be effectively solved by drawing the door and window family through the general model and opening the door and window holes on the wall in advance.

D. Modeling Steps and Key Points of Structural System in Revit Software

For structural system modeling, whether steel structure or concrete structure, the modeling steps basically follow the modeling sequence of elevation grid, column, beam and floor. The accuracy assurance of elevation grid and different component sizes is crucial, because the deviation of a certain location or size may bring chain reaction of a series of problems to the subsequent creation of the whole model, resulting in much rework and revision.

V. BIM Model Integration and Problem Coordination

A. Model Integration and Problem Coordination

When all specialties have completed the creation of their own preliminary model, the model will be integrated and reviewed in NavisWorks. According to the types of collision problems, the coordination work needed can be divided into three categories: intra-specialty coordination, inter-specialty coordination and coordination between site and single unit. Intra-specialty coordination mainly includes internal coordination of civil engineering and mechanical and electrical specialties, which is often revised and solved in combination with drawings and design before integration. Inter-specialty coordination includes mutual coordination among civil engineering, steel structure, light-gage steel and mechanical and electrical specialties. This part of coordination needs to be combined with the actual situation of the construction site. Each participant shall put forward modification opinions according to the actual problems, discuss and make decisions together, and then complete the model revision within the specialty according to the final changed design. The coordination between AD and single unit mainly focuses on POC (point of connection) of the pipeline. POC refers to the pipelines connecting municipal pipelines to the single building. The design of the site and single building is completed by different teams. Therefore, during the design, there are inevitable errors in the connection.

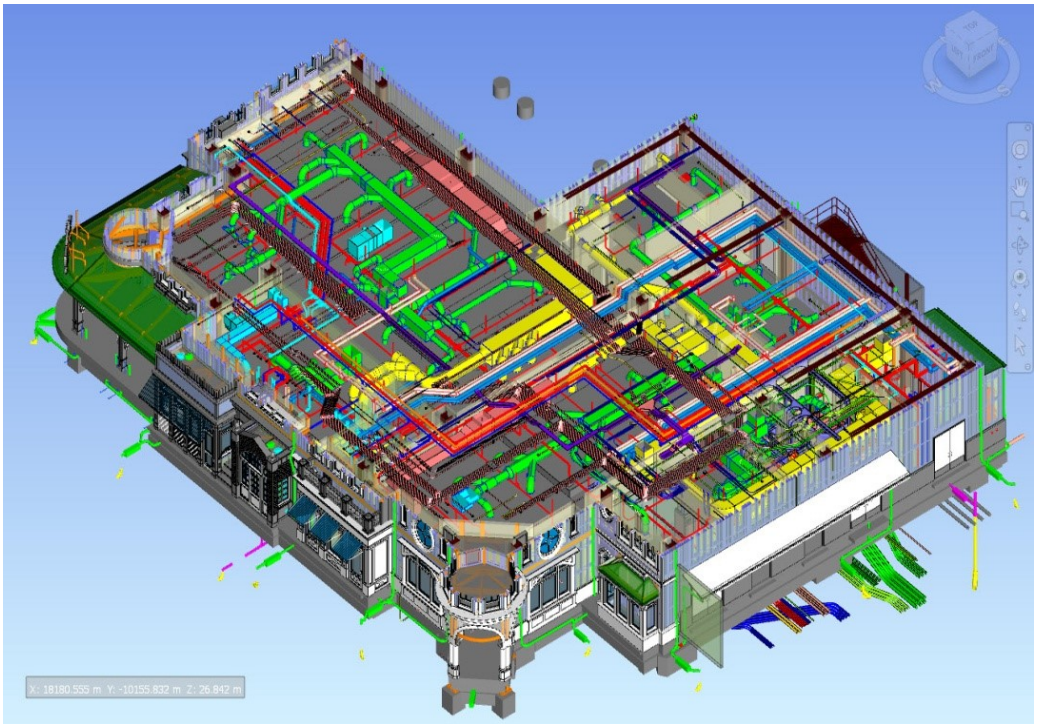
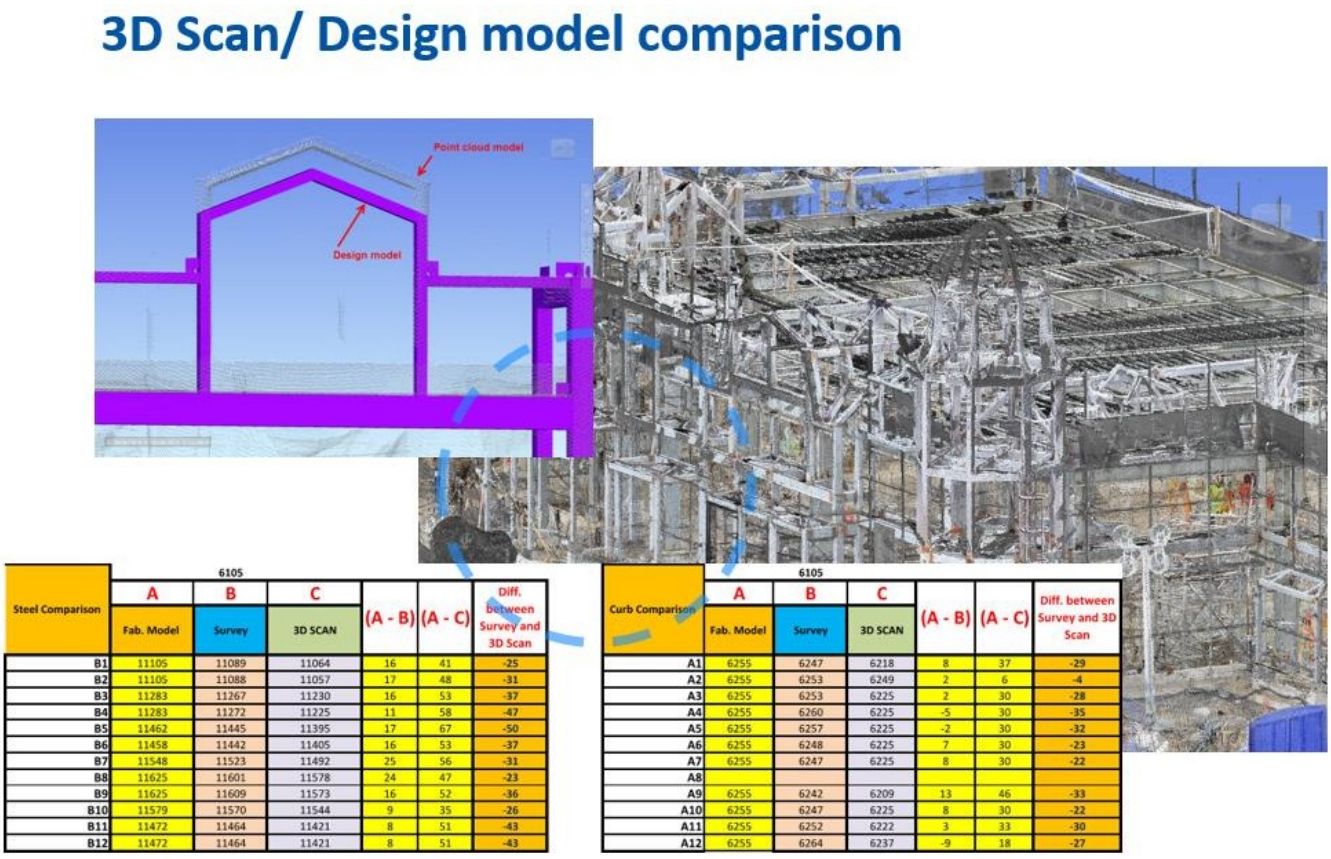


Fig. 4 BIM integration

B. Application of 3D Scanning

With the deepening of the project construction progress, there will be a lot of collision and coordination problems on the construction site, especially for the architectural ornament components, because of its strict accuracy requirements, and the structure construction often results in a large number of design changes due to external reasons, which makes the accurate installation of building decoration components very difficult. It is very difficult to coordinate the prefabricated components in the processing plant. Therefore, the Disney project introduced 3D laser scanning technology to scan the installed structural components to form point cloud data. BIM engineers compare the point cloud data with the design model, find out the construction deviation, and feedback the situation that affects the installation of building decoration components to the designer. The designer shall make design modification according to the deviation, then transfer the modification to the processing plant for modification or reproduction, and finally transport it to the site for installation. Such a process can fully ensure the smooth installation of architectural ornament components. In addition, 3D scanning can also be used as one of the inspection methods of construction quality. By comparing the scanning model with the design model, the construction deviation is clear. Thus, the construction problems can be found in advance, and the subsequent project progress can be guaranteed.



Steel Comparison	6105 A	B	C	(A - B)	(A - C)	Diff. between Survey and 3D Scan
	Fab. Model	Survey	3D SCAN			
B1	11105	11089	11064	16	41	-25
B2	11105	11088	11057	17	48	-31
B3	11283	11267	11230	16	53	-37
B4	11283	11272	11225	11	58	-47
B5	11462	11445	11395	17	67	-50
B6	11458	11442	11405	16	53	-37
B7	11548	11523	11492	25	56	-31
B8	11625	11601	11578	24	47	-23
B9	11625	11609	11573	16	52	-36
B10	11579	11570	11544	9	35	-26
B11	11472	11464	11421	8	51	-43
B12	11472	11464	11421	8	51	-43

Curb Comparison	6105 A	B	C	(A - B)	(A - C)	Diff. between Survey and 3D Scan
	Fab. Model	Survey	3D SCAN			
A1	6255	6247	6218	8	37	-29
A2	6255	6253	6249	2	6	-4
A3	6255	6253	6225	2	30	-28
A4	6255	6260	6225	-5	30	-35
A5	6255	6257	6225	-2	30	-32
A6	6255	6248	6225	7	30	-23
A7	6255	6247	6225	8	30	-22
A8						
A9	6255	6242	6209	13	46	-33
A10	6255	6247	6225	8	30	-22
A11	6255	6252	6222	3	33	-30
A12	6255	6264	6237	-9	18	-27

Fig. 5 3D scanning

VI. Summary

A. Benefits of BIM Application for the Project

The traditional design and construction method of the Shanghai Disneyland ME&G project is difficult to meet the strict requirements of project quality and schedule because of its large building volume, complex and changeable structural form, many participating units and complex specialties. The application of BIM technology has greatly improved the design and construction efficiency and accuracy of the project, which are mainly reflected in two aspects. First, after the BIM 3D model is generated, engineers of different specialties can discuss the problems based on the same model, save the workload of reading lots of drawings, and save a lot of time. Second, in the process of construction drawing design or in-depth design, the model can provide the designer with a complete concept of three-dimensional space, and successfully avoid hundreds of large and small collisions between pipelines, collisions between building structures and pipelines; thus reducing unnecessary rework and material waste.

B. BIM Application Suggestions for Similar Projects in the Future

There are still many problems with the BIM application of this project. Based on this, some suggestions for BIM application of the same type of construction projects in the future are proposed, mainly including the following points:

1. Improving model transfer efficiency. The preliminary

design of the model in this project is created by Disney design team, and then handed over to the third party for secondary modeling and specialty coordination, and finally delivered to the construction team. Such a model transfer process not only increases the investment time and cost of the project, but also makes the original design intent difficult to accurately reflect in the BIM model. Therefore, the most efficient BIM model transfer mode of a project should be based on the flow of conceptual design, preliminary design, construction drawing design, detailed design, and construction.

2. Creating complete model information. For the deepening design and construction phase, the main geometric information in the model can meet the needs. But for the later operation and maintenance of the project, this information is far from enough. Much information such as component materials, equipment parameters and manufacturers will provide a lot of convenience for the operation and maintenance management after the completion of the construction, and truly realize the application of BIM in the whole life cycle of the project.
3. Improving model LOD. In this project, the LOD of the BIM model still has room for improvement in some local areas. The insufficient LOD of the model will bring many problems to the site construction and installation, increase the coordination work of the site installation and some complex parts will cause design changes and delay the construction progress. Therefore, if the model LOD can be improved in the model deepening phase to meet the needs of site construction and installation, the construction efficiency will be greatly improved and the construction cost will be saved.

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