Collaborative design of prefabricated building architecture and structure based on PKPM-BIM platform

Liu Yunlin[1, 2, *], Zhang Shaojie[34,] Wang Zijian[1], Qiu Ziwen[1] and He Sheng[1]

[1]Anhui Jianzhu University, School of Civil Engineering, 230601, Hefei Anhui
[2]Key Laboratory of Huizhou Architecture in Anhui Province, 230022, Hefei Anhui
[3]Anhui Jianzhu University, School of Architecture and Planning, 230022, Hefei Anhui
[4]BIM Engineering Center of Anhui Province, 230601, Hefei Anhui

Abstract. Compared with traditional cast-in-place concrete buildings, prefabricated buildings have many advantages and meet the strategic requirements of national sustainable economic development, which has become the development direction of the construction industry. BIM (Building Information Modeling) simulates the real Information of buildings through digital Information, which has the characteristics of visualization, coordination, simulation, optimization, drawing availability and so on, and improves the efficiency of multi-professional collaborative design of prefabricated buildings. This paper mainly studies the advantages of collaborative design of prefabricated buildings based on PKPM-BIM platform for architecture and structure majors. Research shows that the application of BIM can improve the efficiency and quality of multi-professional collaborative design of prefabricated buildings.

1 Introduction

Prefabricated buildings have the characteristics of standardized design, factory production, construction and assembly, and integrated decoration[1].Compared with traditional cast-in-place concrete buildings, prefabricated buildings are more efficient, energy-efficient and safe[2]. The traditional collaborative design method, with great difficulty in professional communication and heavy workload, has brought great obstacles to architectural design. The PKPM-BIM platform can realize the collaborative design of prefabricated buildings for different majors [3].

2 Application of PKPM-BIM in prefabricated buildings

According to a study by PWC, the application of BIM can shorten the overall construction project cycle by 5%, among which communication time can be saved by 30% to 60%, the information search time can be saved by 50%, and cost can be reduced by 5%.The application of PKPM-BIM has significantly accelerated the process of project information exchange, and also saved the project cost. Effectively use the coordination of BIM for multi-specialty coordination and integration to reduce unreasonable change schemes or problem change schemes in the project. With the visibility and map availability of PKPM-BIM, the architectural design will be more reasonable and efficient.

3 The example analysis

3.1 Example background

In a high-rise building with a prefabricated shear wall structure, students majoring in architecture and structure cooperate to complete the design of the building and structure.

3.2 Traditional collaborative design

3.2.1 Process description

In the traditional architectural design method, the major of architecture provides two-dimensional CAD drawings and geometric models to the major of structure, and then the major of structure builds the structural calculation model according to the design scheme of architecture, carries out structural calculation analysis, and feedbacks the structural problems of architecture to the major of architecture according to the calculation results, and puts forward Suggestions on model modification. According to the opinions of the structural major, the architectural plane drawing shall be revised and the model shall be adjusted.

3.2.2 Disadvantage

1) Communication between majors is difficult. In the traditional collaborative design mode of architectural

* Corresponding author: 272205549@qq.com

structure, the major of architecture and the major of structure mainly rely on language description and CAD drawings to convey their ideas, which is easy to communicate in a timely manner and make mistakes in understanding. In general, the modification of the building structure does not exist alone. Often, the modification of a certain place will cause the change of many places, which will increase the workload of collaborative design and the difficulty of professional communication. The unintuitive and inconvenient communication between professions greatly reduces the work efficiency of designers.

2) The workload is tedious and the design quality cannot be guaranteed. In the traditional collaborative design mode of architectural structure, both architectural scheme design and structural design need to draw a large number of CAD plans. In addition, when collaborative adjustment of architectural structure design scheme, a large number of changes will be made to the drawings. In the process of assembly building design, it is also necessary to deepen the design of prefabricated components. This not only brings huge workload, but also may lead to drawing errors or inconsistent architectural structure information due to the carelessness of the draftsman, making the drawing unusable and wasting a lot of time.

3.3 Collaborative design based on pkpm-bim platform

The design method adopts BIM forward collaborative design based on "building", and the main design process is shown in fig 1.

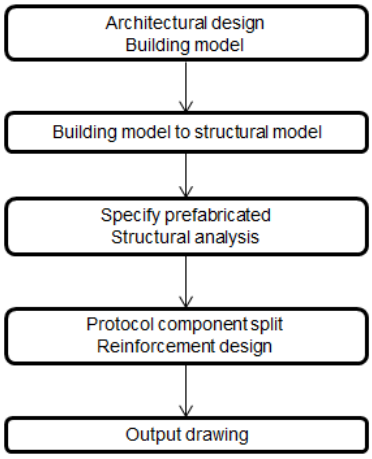

Fig 1 Forward collaborative design process of BIM based on "building" as the leader.

3.3.1 Architectural design

1) Architectural scheme design

Architectural specialty according to the architectural style, the location of the terrain conditions and other factors, building facade design and architectural graphic design. In the process of architectural design, we should follow the principle of "less specification, more combination" of prefabricated buildings, which not only requires beautiful buildings, but also meets the requirements of prefabrication rate.

2) Scheme optimization design and deepening design

After the completion of the architectural scheme design, BIM technology was used to optimize the design and adjust the building's lighting analysis, energy saving analysis, etc. Finally, the base and structural models were supplemented with the assembly model, and the assembly construction of the model was further designed.

3.3.2 Structural design

1) Building model to structural model

The structural major shall import the construction data on the PKPM-BIM platform, and timely communicate with the architectural major to modify the construction plan for the obvious unreasonable structure. After the structural calculation model is completed, the floor load and the load between beams should be arranged according to the specifications and actual conditions. Finally, the precast properties should be specified for the precast construction, and the calculation should be prepared.

2) SATWE calculation

SATWE is a kind of finite element analysis software based on shell element theory, which is designed for the analysis and design of high-rise buildings. After the structural modeling and load loading is completed, the calculation of relay SATWE can be analyzed as a whole. Before the model calculation, the corresponding parameters should be correctly input according to the specifications and the model should be pre-processed.

3) Coordinated model adjustment

Combined with the calculation book output after SATWE calculation and "technical specifications for high-rise concrete structures" JGJ 3-2010 and "code for seismic design of buildings" GB 50011-2010 (2016 edition), the six macro-control indicators of the building: cycle ratio, displacement ratio, stiffness ratio, shear weight ratio, stiffness ratio and axial compression ratio were checked to determine whether the structure form is reasonable. If it is not reasonable, different majors can jointly adjust the model on the collaborative platform. Taking period ratio as an example, "period ratio" is mainly used to control the torsion effect of structure and reduce the adverse influence of torsion on structure. Requirements in the regulation/specification: cycle ratio = first period of twist (T_t)/ first period of translation (T_1) $\leqslant$0.9.A good structure type, the first and second natural vibration period is translational, the third natural vibration period is twisting. If "period exceeds standard", come up from the phenomenon saying is torsion period advanced, increase the section size of beam, column around the building so, prevent building torsion when the earthquake. The PKPM-BIM platform also provides collision detection function, which can help building and structure professionals to find out where there are conflicts in the model and make timely corrections.

4) Precast element split design and reinforcement calculation

There are four main ways of deepening split design of prefabricated components: automatic design, interactive split, interactive layout, component editing and attachment layout. According to the requirements of the code, grasp the concept of "less specification, more combination" to split and deepen the design of Precast element and complete the collision inspection, and finally complete the reinforcement of the calculated results before the relay.

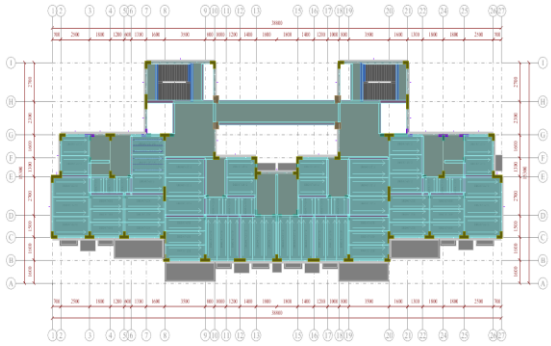

Fig 2. Precast element split design drawing of a standard floor.

5) Output construction drawings

The PKPM-BIM platform can automatically generate various construction drawings and construction details according to the model to facilitate construction and guide production.

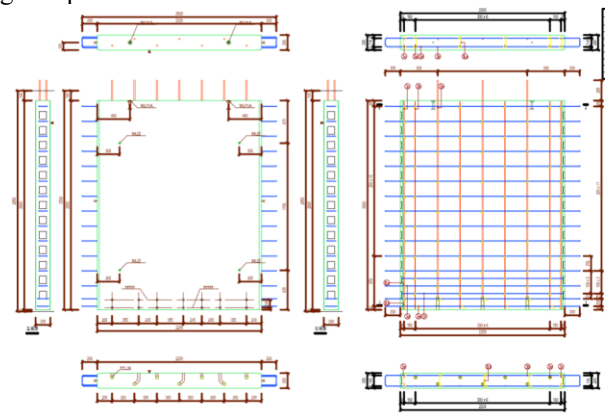

Fig 3. Detail drawing of an interior wall.

3.3.3 Advantages over traditional collaborative design

The PKPM-BIM collaborative platform is used to visualize the building model, strengthen the communication and cooperation between architecture and structure majors, and ensure the consistency of information between architecture and structure. BIM's characteristics of parameterization and drawing availability facilitate collaborative adjustment of models by architectural structure majors, reduce the workload of drawing by architectural and structural majors, improve work efficiency and guarantee work quality. For prefabricated buildings, PKPM-BIM collaborative platform can be used to control and supervise the design of prefabricated components, reduce design errors and errors, guide the production of prefabricated components, and improve the efficiency of prefabricated building design.

4 Conclusion

The visibility of BIM directly connects the two majors of architecture and structure, promotes the organic integration of architectural structure design, reduces communication barriers between professionals, greatly shortens the design cycle of architecture and reduces repetitive work. The scientific analysis method is used to analyze the building structure, which ensures the design quality of the structure. The parameterization and drawing availability of BIM facilitates the collaborative modification of models by architectural structure majors, reduces the workload of designing drawings, and ensures the quality of drawings. Compared with the traditional collaborative design of building structure, the PKPM-BIM collaborative platform can obviously guarantee the design quality and greatly improve the design efficiency.

For prefabricated buildings strongly advocated by the state, collaborative design of architectural structures based on PKPM-BIM platform can realize comprehensive management of the design process and promote exchanges and cooperation among multiple professional designs. It also improves the production efficiency of prefabricated components and promotes the rapid development of prefabricated buildings.

Acknowledgement

The authors appreciate the financial support from the National Key Research and Development Program of China (2016YFC0701802, 2016YFC0701507); Anhui Provincial Natural Science Foundation (1908085ME144); "Modern construction industry worker training" research (2019FWCN2282); 2019 Shanghai luban software co., LTD. ministry of education production university cooperation education project "construction of practice base of architecture based on BIM Technology" and "Construction of practice base of civil engineering based on BIM technology" and 2019 Hangzhou pingming security control information technology Co., Ltd. ministry of education production university cooperation education project "Construction of practice base of civil engineering based on BIM Technology" .

References

1. Ma Lin. On prefabricated building technology ([J]. Smart city, 2019, 5(16):30-31.)
2. Li Tian. Application research of BIM collaborative design in an architectural design project [D]. Southwest Jiaotong University, 2013.
3. Zheng huizhen. Application of pkpm-bim software in prefabricated concrete structure -- a case study of assembled integral concrete frame structure. Journal of liming vocational university, 102(01), 91-97. (2019)
4. Mao Xuelin. BIM technology in the application research on collaborative design for building structure. (Doctoral dissertation, Chengdu University

of technology, 2018).
5. Fang Wanrong. Building structure of collaborative design based on BIM technology research. (Doctoral dissertation, wuhan university of science and technology, 2013).
6. Dai Wenying. Research on prefabricated architecture based on BIM technology [D]. Wuhan University, 2017.
7. Yao gang. Research on key elements and integrated application of BIM based collaborative design of industrial housing [D]. Southeast university,2016.
8. Bai shu, zhang yankun, han feng, zhang dehai, li wei. Application value analysis of BIM technology in prefabricated buildings [J]. Construction economics,2015,36(11):106-109.
9. Yan Liu, Sander van Nederveen, Marcel Hertogh. Understanding effects of BIM on collaborative design and construction: An empirical study in China[J]. International Journal of Project Management, 2016.