

Thoughts on Informatization of Prefabricated Building

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Abstract. Prefabricated buildings are the reorganization and optimization of related resources such as design, component production and prefabricated construction, which are the inevitable result of market selection, industry development and productivity improvement. Prefabricated overall correlation, parallel design, modular combination and generalization have transformed the construction industry from a traditional sector to an industrial sector and presented some features of informatization. On account of the limitations of BIM, the low degree of informatization of component manufacturing and key node technology research, informationization of prefabricated technology and design has not yet taken shape, which restricts informationization of prefabricated building. Overcoming the inadequacy of building an integrated information system can help modernization of the construction industry.

1. Introduction

Prefabrication (prefabricated building), because of the contributing role it plays in advancing industrial restructuring and upgrading, facilitating energy conservation and environmental protection, and improving architectural safety and addressing overcapacity, is promoted by the government. Yet, its development is hindered due to some limitations. Prefabricated buildings result from conversion from the traditional mode to the industrialized mode, but in highly industrialized areas, informatization has become the key to furthering industrialization. There are two main challenges that limit the development of prefabricated buildings: industrialized conversion and further informatization. From the perspective of informatization, factors that limit the development of prefabricated buildings are analyzed and solutions are explored herein so as to increase the level of informatization in prefabrication and promote modernization of the construction industry.

2. Prefabrication – Result of Industrial Development

Prefabricated buildings refer to buildings assembled in the construction site with components including wallboards, laminated slabs, balconies, air-conditioning panels, staircases and beam columns prefabricated in the workshop. Prefabricated buildings mainly include the following categories: block buildings, board-and-plate buildings, boxed buildings, framing board buildings and lift-slab and lift-flat buildings.



2.1 Prefabrication – Necessity for Industrial Improvement

The traditional on-site construction method features low efficiency in utilization of resources and energy, large-volume waste discharge and severe pollution due to the dust and noise incurred. In contrast, prefabricated buildings show better performance in energy conservation, material-saving and emission-reduction. According to research and statistical analysis, prefabricated buildings, compared with those built through the traditional on-site concrete-pouring construction method, consume much less timber, concrete and mortar, thermal insulation materials and construction water and electricity. Prefabricated buildings produce 80% less construction waste than those built through the traditional on-site construction method, and result in less environmental pollution caused by carbon emissions, dust and noise, so it contributes to improving the urban environment, increases the holistic quality and functions of the buildings and promotes ecological melioration.

Prefabrication promotes modernization of the construction industry, reduces resource consumption and avoids repetitive work, so it is a key breakthrough point to achieve sustainable development of the construction industry.

2.2 Prefabrication – Historic Choice of Industrial Development

The prefabricated building sector in China has gone through four stages (with housing components as the study case). The first is the stage of prosperity of the industrialized residential building system – in this stage, large structural housing components develop rapidly and become the focus of production, with few sanitary ware coming into being; the second stage is the stage of development and transformation of housing construction. In this stage, residential houses are commercialized and housing components achieve rapid development along with the development of commercial houses. Meanwhile, housing parts become more diversified in type with improved quality. The third is the stage of development of industrialized housing components. After the initiative of housing industrialization started in 1996, the government issued standards for quality of different housing components, lots of new technologies came forth and the concept of component-integration was proposed. The concept of integrated design of kitchen and bathroom wares emerged, and multiple factors including plane layout, area and size, equipment installment and piping began to be taken into account. The forth is the stage of rapid development of prefabricated buildings. Since 2015, the government has issued documents (Table 1) to promote prefabrication nationwide and advance industrial restructuring.

Table 1. Government Documents in the Rapid Development Stage of Prefabrication

Time of Issuance	Title	Content
End of 2015	Standard for Assessment of Industrialized Building	To promote prefabrication nationwide and make breakthrough in 2016
2015.11	Modernization Outline of Construction Industry	To increase the proportion of prefabricated buildings in new buildings to 20% in 2020 and 50% in 2025.
2016.02	Guiding Opinions for Advancing Development of Prefabricated Buildings	To develop prefabrication featuring prefabricated concrete structure, steel structure and modern timberwork structure in light of local actualities, and strive to increase the area of prefabricated buildings to 30% of the area of new buildings within 10 years
2016.03	Report on the Work of the Government	To enhance development of steel structure and prefabricated buildings, improve the engineering standard and quality of construction
2016.09	Guiding Opinions for	Defined the key areas for development of

	Promoting Development of Prefabricated Buildings Issued by General Office of the State Council	prefabricated buildings and steel structures, the goal of the proportion of prefabricated buildings in new buildings and key development cities
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These documents demanded devoting more to developing the steel structures and prefabricated buildings and aimed to enhance the standard and quality of building construction. They have also defined the areas for promotion of prefabrication, the proportion that prefabricated buildings are going to occupy in new buildings and the key cities for development of prefabrication. This stage is characterized by fast development of prefabrication.

3. Prefabrication – Conversion from Traditional Construction to Industrialized Construction

Prefabrication is, in essence, application of the concept of integration to the construction industry, a way to optimize, adjust and integrate interconnected components into a whole according to actual demands. The major work on the construction sites of prefabricated buildings which integrate construction with furnishing is assembling, but the traditional concrete-pouring procedures are largely reduced. Successful application of advanced construction techniques and management theories, such as concurrent engineering, group technology, large-scale customization, precision production and intelligent manufacturing, in the precision production industry has provided an optimal model for implementation of the concept of integration in the construction industry. Application of many advanced theories and technologies into the construction industry has boosted development of prefabrication and furthered the industrialized level of construction.

Digital management of workshops and assembly on the construction site have increased the standard of components and improved efficiency. Standardization of design, manufacturing and assembling of prefabricated buildings results from the deepening of industrialization of the construction industry. Compared with the traditional concrete-pouring method, prefabrication integrates the features of industrialization and informatization, which are reflected in the following aspects:

3.1 Interconnection among Different Parts in Prefabrication

Prefabrication, by integrating design, construction, production and processing into a holistic system, coordinates building design, equipment design, structural design and furnishing design. Efficiency of communication and cooperation in the process of design, manufacturing and fabrication is positively correlated to conservation and utilization efficiency of resources. The degree of standardization and informatization may affect the integrated level of the building components.

3.2 Concurrent Design of Different Parts in Prefabrication

Design of prefabricated buildings changes the traditional order in which furnishing design comes after completion of building design (including structural design and equipment design). It embodies furnishing design into the initial stage of building design and layout design into the stage of furnishing design. Furnishing design can, from a microscopic perspective, deduce or confirm the effect of the macroscopic building design; concurrent design can, from interior to exterior and from small to large, judge whether the plane layout, the space topology and even the architectural structure are rational. Concurrent design with efficient communication and cooperation among different enterprises can realize prime integration of resources and optimize the design process.

3.3 Modular Integration in Prefabrication

Components of prefabricated buildings can be divided into independent modules. Such modularization encompasses modular decomposition and modular integration, which gives rise to more complicated and intricate systems. Modular design of prefabricated buildings incorporates such modules as the

holistic building, the building materials and furniture, demanding further integration of industrialization and informatization in design, manufacturing and assembly.

Assembly of component modules has reduced development cost of components. As technologies grow more complex, it needs more than one enterprise to cooperate and develop multiple components, which turns out to have controlled the cost to the minimum. Modularization decomposes the components into several subsystems or modules, thus enabling different manufacturers to give full play to their strengths. Modularization increases flexibility in the process of design, manufacturing and utilization. As modularization decomposes the integrated whole into several subsystems, the function of the whole will remain intact as long as there is no change in the connection among subsystems. Modularization not only makes the design and production of subsystems (components) more professional, but also facilitates upgrading of the subsystems and hence contribute to their innovation.

3.4 Further Integration of Industrialization and Informatization in Generalization in Prefabrication

In contrast with customization, generalization is standardized production or a way to assemble components according to a universal standard. Generalized prefabrication is an open industrialized construction system, in which the different aspects including component design, building design, furnishing design, component production and construction constitute a whole featuring interconnected innovation. Prefabrication transfers the great deal of on-site construction work to the workshops, engendering many backend manufacturing bases which are independent from each other but cooperate with and rely on each other. Prefabrication realizes efficient and quality assembly of different components on the construction site, creating more diversified interior space.

Generalization of prefabrication diverts the attention of some architects and interior designers to matching and selection of commercial components, and enables them to focus on user demand to compare design solutions and work out the optimal design. Meanwhile, some other architects and interior designers focus more on design of components and details. To implement professionalized and generalized production of components (modules) contributes to increasing the level of automation of production, improves production efficiency and reduces costs. Generalized components can be used in both new construction projects and expansion projects, regardless of the scale and form of projects. Generalization can expand from industrialization of the major project to industrialization of the whole production process of all components.

In general, higher level of generalization means better compatibility and flexibility of the components as well as lower building costs. Though development and improvement of different components are independent, the components in prefabricated buildings are interconnected according to certain standards. These standards, which are usually the basis of generalization, demand that the ports be shared, a universal standard (including rules and precision) be implemented in different production departments and real-time and concurrent cooperation be realized among different departments.

4. Analysis of Causes and Solutions to Increase the Level of Informatization in Prefabrication

Development and promotion of prefabricated buildings is limited by different factors: the standards for prefabrication still fall short of perfection; the system of design integration, production industrialization, construction fabrication and integration of building and furnishing is still to be improved; corresponding technologies, equipment and machines for prefabrication show limited applicability; the level of informatization is still low; the types and specifications of components are limited. Compared with the prefabrication sector which attaches more importance to industrialization, many highly-industrialized sectors take further informatization as the key measure to deepen industrialization, so the prefabrication sector undertakes the double tasks of realizing industrialized transformation and increasing the level of informatization.

Based on analysis from the perspective of informatization, the main causes that undermine development of prefabrication are the limitation of IBM, low level of informatization in development of key technologies and manufacturing of components as well as absence of informatization in

assembly technologies and design. Analysis on these causes is made below to increase the level of informatization in prefabrication and promote modernization of the construction industry.

4.1 Solutions to Limitation of BIM

Informatization of prefabrication shares many concepts with BIM. BIM, short for Building Information Modeling, is an information management tool for project design and construction. It incorporates the information of different phases in the whole-life cycle of the project from project planning, implementation to maintenance into a model and makes the information available for all parties involved in the project. With simulated 3D information of the building, BIM provides data support for coordination between project design and construction and for integration of design and construction. Efficient sharing and transmission of information facilitates cooperation between different parties involved, improves production efficiency, cuts production costs and saves time for the project. In a sense, BIM serves as the basis for informatization of prefabricated buildings.

BIM is a relatively enclosed information application tool which serves the whole life cycle of projects. BIM is devoid of the functions of integrating the information of components and providing an open information platform; besides, the software and plan sketch used to build existing informationized modules cannot be efficiently converted into construction drawings. Due to these reasons, the existing BIM cannot become the informationized platform for prefabrication. Therefore, informatization of prefabrication entails conversion of ideas, extension, system restructuring and software development based on BIM.

4.2 Solutions to the Low Level of Informatization of Components and Key Assembly Technologies

To address the problem of low level of informatization of components, an information platform that incorporates all components can be built to improve the designer's efficiency and strengthen the connection among production departments. Compared with development of construction techniques, the development of rules for check of prefabricated buildings in China obviously lags behind; the increasing demand for corresponding design along with the increasing need for embedded parts of buildings has not been met; insufficient research and development of key fabrication technologies curbs the height of buildings and realization of assembly functions. An information platform with key assembly technologies can increase the link among different production departments and components. The link, on one hand, promotes mechanized improvement of construction tools and modernized innovation of fabrication ways from the perspective of ergonomics, and on the other hand, facilitates training the construction workers with advanced prefabrication concepts and mechanized fabrication methods. Such link can also aggregate useful resources, increase communication among components and the technologies, and promote research and development of components and technologies.

4.3 Solutions to Unachieved Informatization of Building Design

Informatization of prefabrication requires increasing levels of informatization of building design. Development of production force leads to changes in people's life demand and in their aesthetic senses. Consequently, their standard for housing furnishing and decoration increases, which requires adjustment of prefabricated components to meet people's life and work needs. Only people-oriented prefabrication can meet these needs. Moreover, due to unbalanced economic development, difference in people's residential form, life style and aesthetic sense, prefabrication of furnishing and decorative parts of buildings needs to attend to humanistic aspects like personality and health. People-oriented informatization of building design can be realized in two ways. The first is to take a specific consumer group as the target, collect corresponding data and find the common factors and basic law for design to conclude the systematic design information for that specific consumer group. The other is to change the design elements based on "systematic design" to meet people's need for diversified design styles. An information platform with design style libraries cannot only facilitate communication between the designer and the clients, but rennovate informatization of building design.

5. Conclusion

Informatization of prefabricated buildings presupposes conversion of ideas, extension, system restructuring and software development on the basis of existing BIM. With BIM as the starting point, informatization of prefabrication combines the content of system construction and coordinates isolated data through a comprehensive management platform. The goal of informatization of prefabrication is to develop BIM into BIMS, a prefabricated building information system (see Fig.1), which incorporates information of components, information of research and development of key technologies, information of prefabrication technologies and information of design.

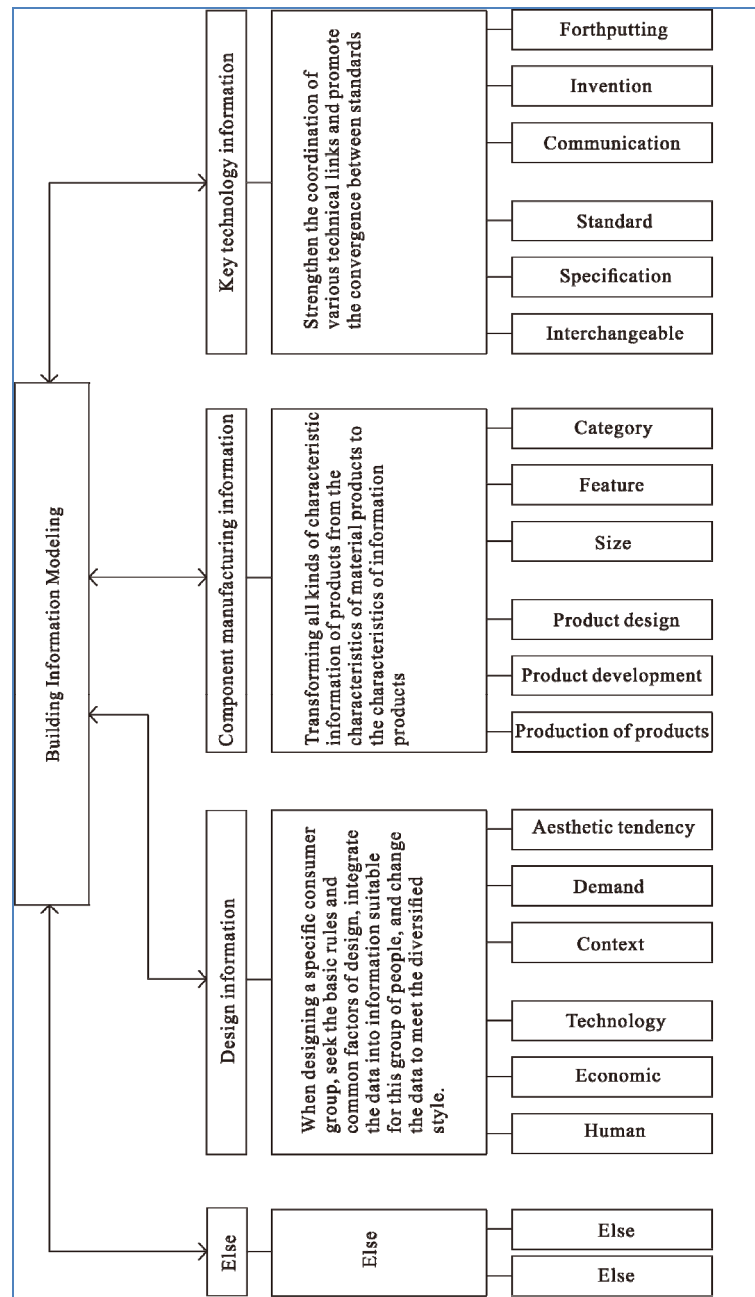


Fig 1. Prefabricated building information system

Full-range data management can help improve the production and organization ways and strengthen enterprises' management. Informatization of prefabricated buildings can promote

modernization of the construction industry, and also improve the quality of people's life and work space.

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