Analysis of the life cycle stage of prefabricated buildings

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Abstract. With the development of China's construction industry, the development of prefabricated buildings has become a national strategy to promote the transformation and upgrading of the construction industry. However, the promotion of prefabricated buildings still faces many obstacles. One of the reasons is the uncertainty of cost. Although existing research has some quantitative research on its economics, few scholars have conducted systematic research. This paper discusses this issue from the perspective of the whole life of the building. Through the literature review method, the whole life cycle of the prefabricated building is divided into seven stages, which lays a foundation for studying the variation factors of the prefabricated building cost.

1. Introduction
Prefabricated building is one of the most studied building types. After the integration of BIM technology and prefabricated buildings, it is necessary to carry out a more standard stage division of the entire life cycle of the prefabricated building. The standard stage division can more accurately evaluate the economic and environmental impacts of the prefabricated buildings, which can better make the assembled buildings take advantage. Due to the relatively high construction cost, poor structural integrity and lack of individuality of the building, the prefabricated building has greatly restricted the development of the prefabricated concrete building in China[1]. On September 27, 2016, the General Office of the State Council issued the “Guiding Opinions on Vigorously Developing Prefabricated Buildings”, and developed assembly-type buildings such as fabricated concrete structures, steel structures and modern wood structures according to local conditions. “The Chinese government has proposed to use 10 years or so to make the proportion of prefabricated buildings to 30% of new construction area[2].” The document points out that the development of prefabricated buildings is a major change in the way of construction. It is an important measure to promote structural reforms on the supply side and the development of new urbanization. Prefabricated buildings can effectively improve labor efficiency, save energy resources, reduce environmental pollution caused by construction, improve quality and safety, facilitate the deep integration of construction industry and information industrialization, foster new industries and new kinetic energy, and promote the elimination of excess capacity[3]. The stage division of the prefabricated building life cycle is an indispensable indicator for evaluating the economic benefits of prefabricated buildings. There is no clear standard in China. This paper aims to analyze the functions of the entire life cycle of a prefabricated building. The standard for the division of the life of a fabricated building is clearly stated.
2. Traditional building life cycle stage
The traditional life cycle project of traditional buildings refers to the whole process of building from “cradle to grave”, and the time span is long. Therefore, the stage of the whole life cycle must be reasonably divided. According to the specific management situation of China's engineering cost, the whole life cycle engineering cost is divided into the following stages: investment decision stage, design stage, project implementation stage, completion acceptance stage and operation and maintenance stage.

3. Prefabricated building life cycle stages
Due to the particularity of the prefabricated building, the process is more complicated than the traditional building. The prefabricated building increases the production process, installation process and transportation process of the component. Therefore, it is necessary to re-divide the entire life cycle of the assembly building.

Some scholars in our country have divided the whole life cycle of fabricated buildings in the article. Wei Hu et al. divided the whole life cycle into design stage and building component manufacturing in the application research of BIM in the whole life cycle of fabricated buildings. Five phases: stage, assembly and construction phase, and operation and maintenance phase[4]. Yingying Liu and other scholars pointed out in the study of the whole life cycle of fabricated buildings that the five phases of the prefabricated building life cycle are the design phase, the prefabricated component production phase, the prefabricated building construction phase, the assembly and construction operation and maintenance phase[5].

Some scholars divide the life cycle into four phases: the planning and design phase, the manufacturing phase, the construction phase, and the operation and maintenance phase[6].

After investigation and interviews on fabricated buildings, there are many factors in the difference between the cost of fabricated buildings and traditional buildings, and the transportation process of assembled components also has great cost changes. However, Chinese scholars consider that a large part of the entire life cycle of fabricated buildings ignores the transportation process of fabricated buildings. By file comparison the life cycle of a prefabricated building can be divided into: Decision stage, design stage, component production stage, component transportation stage, construction stage, sales stage, post-maintenance and demolition stage.

4. Analysis of the various stages of the life cycle of fabricated buildings
4.1. Decision-making stage of prefabricated buildings
The cost involved in the decision-making stage of the prefabricated building is firstly to prepare the investment estimate, and the cost control is to control the cost influencing factors reasonably. In the absence of a large amount of data, it is difficult to prepare a reasonable and optimal assembly-type construction investment decision-making plan. Through reasonable control of the assembly rate of the prefabricated building, refine and deepen the project feasibility study, deepen the different design schemes. Compare and select, thus setting a reasonable target cost and calculating the optimal investment estimate.

Secondly, the impact of general contract management, the assembly-type construction technology in the industrialization of construction has been widely promoted, and the management level of the general contract at the construction site also determines whether the project is going smoothly. At this stage, all provinces in China clearly pointed out the work objectives and specific promotion measures in the documents related to the prefabricated buildings. However, some areas have great flexibility in implementation, so that the prefabricated buildings cannot be effectively landed. The promotion of prefabricated buildings will be implemented from the source, that is, the specific projects of assembly and construction, and the construction standards of prefabricated buildings will be clearly implemented in the decision-making stage[7].
4.2. Design stage of a prefabricated building
The scientific rationality of the planning and design of the prefabricated building is crucial to the control of the cost, quality and duration of the overall project. This requires that the technical solutions formed in the design and preliminary design stage of the prefabricated building plan are scientific and reasonable, and the deepening design of the components and the construction and organization design are convenient and feasible.

In the prefabricated building design stage, node design, technology selection, and construction drawing design are required. Generally speaking, the prefabricated building design stage is the focus of the project's full-life cost influencing factors. In the design stage, it should be analyzed according to the characteristics of the building, and the building flat-face decoration engineering should be carried out and rationalized. Through a 1:1 simulation of the machining steps, the worker can clearly understand the operating process of each node. Avoid the loss of work, rework, scrapping, etc. caused by the inability to bind or mis-bundle some complex prefabricated components due to unclear drawings and insufficient experience of workers[8].

In the technology selection stage, detailed analysis of component prefabrication plans, splitting plans, installation and maintenance plans, etc. should be carried out. In the construction drawing stage, it is necessary to comprehensively consider production, transportation, installation and construction according to the prefabricated component design.

4.3. Prefabricated component production stage
Compared with traditional buildings, the prefabricated construction is more “green” in the construction process. Emphasis on the construction concept of energy saving, land saving, water saving and material saving. More meet the requirements of China for low-carbon environmental protection, the production stage of prefabricated components is the most significant part of the difference between fabricated buildings and traditional buildings. There are many factors affecting the cost at this stage. Standardization of components such as beams, slabs, columns, and stairs will reduce the number of molds and the complexity of the manufacturing process. Due to the change in construction methods, the technology will be greatly innovated, and the technical level of the component factory personnel will affect the quality of the construction and delivery time.

In the mold production process, the mold standard type is poor, the versatility and interchangeability are poor, the mold input amount is large, the turnover frequency is small, and the life cycle is short. These factors will lead to an increase in mold cost. Therefore, large-scale production will increase the amortization of the model to reduce costs. In the production and use stage of the mold, the mold must be accurately positioned, and the standard design of the component dimensions must be met. The key factor in the development of prefabricated buildings is to rely on the advancement of technology to improve production efficiency, and the way to improve production efficiency is to upgrade the technical level. Therefore, improving the technical learning and technological innovation of technicians to solve the difficulties of assembly technology and solving the problem of standardization of fabricated buildings is an important way to promote the development of fabricated buildings.

4.4. Prefabricated building component transportation phase
Improving transportation efficiency and reducing transportation cost are the main countermeasures for controlling the cost of the assembled building components during transportation. Before the components are transported, they must have reasonable lifting and transportation plans, and be fully prepared. The location of the component factory determines the transportation cost, and the transportation mode of the component is also within the consideration of the construction party. Before the transportation of the component, the route and the transportation vehicle shall be specified, and the quality and quantity requirements of the construction shall be checked.
In the process of component shipment, to ensure a scientific and reasonable shipping sequence, it is necessary to ensure that the flat and solid transportation road can not only improve the transportation efficiency, but also the components will not be damaged during transportation.

4.5. Construction phase of prefabricated buildings
Assembled building components have the characteristics of large volume and self-importance. Most of the machinery used on the construction site is large-scale machinery, which increases the use area of the prefabricated building construction site, so to a certain extent whether the binding assembly-type building can Normally, the prefabricated components at this stage can be reused many times, which results in amortization of the multiple use after the components are formed once, thereby theoretically reducing the cost by increasing the number of uses and time.

From the characteristics of the prefabricated building, the prefabricated building is to put a part of the work that would otherwise need to be on the construction site in the factory. The installation steps carried out on site mainly include prefabricated component approach inspection, wall panel hoisting construction, hoisting, precision control and inspection, slab hoisting construction, and sleeve grouting construction[9]. In the construction phase of prefabricated concrete buildings, the installation of prefabricated components is very important. The installation sequence is generally: tying, lifting, seating, temporary fixing, correction, and final fixing.

4.6. Sales stage of prefabricated buildings
As the prefabricated building is still in the stage of development and consumer acceptance, the control of the market by the enterprise depends on the government's policy orientation and consumer acceptance of the prefabricated building. In the current situation, many developed cities and more developed cities have a large number of The prefabricated buildings have emerged, and the demand for the market has driven the development of the fabricated construction industry to some extent. However, the relevant policy systems and policy support are relatively slow, which can cause certain obstacles to the development of assembly. In the market environment, with the continuous development of the construction industry, assembly-type buildings have received some attention, but many cities are still in the development stage, so the construction units maintain a higher cautious attitude in the sales stage.

4.7. Post-construction building maintenance and demolition stage
The entire life cycle of a prefabricated building is closely related to BIM, and the process of post-maintenance and demolition is inseparable from BIM. The model of BIM completion acceptance is the basis of operation and dismantling and dismantling. It can be better handled during operation and maintenance. The BIM model includes prefabricated building design, production, construction and information parameters modified during the construction process. The required information is effectively labeled and processed. For example, the quality label is divided into quality common disease, model engineering and technical review, which is easy to manage. BIM's collaborative platform provides simultaneous information on the building's full range of expertise, including the performance of the building, etc[10]. The third party can also preview the building events based on the BIM model roaming mode, formulate emergency response plans, improve the cost waste in the traditional mode and lack the data support in the management, and realize the information operation and maintenance in the true sense. Increase the efficiency of use of prefabricated components and save costs more efficiently.

5. Summary
In summary, as China's national strength continues to improve, people's expectations and requirements for the construction industry continue to increase, and there are new requirements for improving the production efficiency of the construction industry. In order to meet the needs of China's social development, the construction industry must carry out reforms and innovations that are advancing with
the times. The prefabricated building is the development direction of the building line. However, for the prefabricated building with the characteristics of green building, the application of the prefabricated building greatly improves the work efficiency, reduces the construction cost and reduces the environmental pollution. The research and promotion of prefabricated buildings has promoted the development of the subsequent construction industry[11]. However, for the development of assembly, the formulation of standards is an urgent task, and the division of the whole life cycle is an important part of standard setting. Through research and interviews, this paper finally divides the whole life cycle into decision-making stage, design stage, component production stage, component transportation stage, construction stage, sales stage, post-maintenance and demolition stage. The division of the life cycle stage paves the way for further study of factors affecting the cost of fabricated buildings.

Acknowledgments
This work was supported by the S&T Foundation Platform of Qinghai Province (Grant No. 20180302-zjc0074). Dan Zhang is the corresponding author.

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