

## The Research on Project Cost of Housing Industrialization

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**Abstract.** The difference between housing industrialization and traditional building are development model and process flow. The way of measurement and valuation for housing industrialization has changed. This paper compares the cost of housing industrialization with traditional building. The purpose is to border the cost of housing industrialization and lay a theoretical basis for housing industrialization cost. It figures out the boundary and constitution of construction project cost under the industrialization pattern before the large-scale development of the housing industrialization. Only figure out the intension and extension of the project cost can we effectively make a scientific contrast of the project cost. It makes a qualitative analysis of the constitution and characteristics of the project cost in the broad sense. It offers reference for the accurate calculation of the project cost of housing industrialization and provides development suggestions.

### 1 Current status of the housing industrialization cost research

The concept of housing industrialization has been introduced to China for more than 10 years. In order to promote the housing industrialization, many local governments have introduced a series of preferential policies; real estate developers, constructors and equipment suppliers have taken an active part in the practice of specific projects. As a result, model projects and model bases of industrialization have been emerged in succession suddenly. But the true meaning of housing industrialization is not be popularized in folk. From the perspective of industrialization development in other countries, industrialization is the inevitable outcome of the development of construction industry to a certain stage, but why China delays the promotion? There are two main reasons: one is the lack of perfect and systematic supporting policies of housing industrialization; the other one is the higher project cost of housing industrialization. About how to reduce the project cost of housing industrialization, the industry has many suggestions. For example, Xu Yuanming points out that the high costs of residential industrialization is mainly from the construction costs, such as the division of upstream and downstream of the industry chain, non forming the scale; high logistics costs; improper structure selection and the lack of skilled personnel and so on [1]. Gu Mingwang proposes that housing industrialization is made up of price A (the costs of raw materials and machinery) and price B (the labor costs); the obtained architectural value consists of value C (the value of service function) and value D (the time value); the

production mode of traditional architecture is  $1A+1B=1C+1D$ . The effect of housing industrialization is to reduce the expenditure of price A and price B, but to increase the value profits of C and D [2]. Han Xiaokui puts forward that the costs budget should be done before the design scheme is determined. The evaluation of the main costs of prefabricated components of housing industrialization is mold sharing costs and transportation costs. During the design process, it is necessary to compare the effect of different schemes on the reuse rate of mold and transportation efficiency as well as improve the product costs-effective [3]. Through the cases comparison, Wang Shuang finds that PC components production and installation fee can widely increase the project cost of housing industrialization. The prefabricated rate in China is only 15-20% while the increment of construction and installation fee is up to 20%-50%. Though the prefabricated rate of North America and Japan are up to 50%-75%, the cost is being controlled effectively. Based on this comparison, a series of improvement measures are put forward [4]. By means of the principle of life cycle, Cheng Fenfen divides the costs of housing industrialization into three parts: the construction costs, using costs and removal costs. Through comparing with cases, it can draw out that with the enlargement of architectural area, the saving costs of the life cycle will be more and more and the advantage of industrialization cost will become more apparent [5].

Considering opinions above, the author thinks the top priority is neither argues whether the project cost of the housing industrialization is lower or that of traditional on-site building is lower nor proves that there are many ways to reduce the project cost of housing industrialization. We

should figure out the boundary and constitution of construction project cost under the industrialization pattern before the large-scale development of the housing industrialization. Only figure out the intension and extension of the project cost can we effectively make a scientific contrast of the project cost. Under the current bill valuation mode, it is suggested to increase the branch sub-item projects which are corresponding to the housing industrialization, and make relevant adjustments in order to welcome the promotion of housing industrialization better.

## 2 SI system of Housing industrialization

The housing industrialization is the fundamental change of the construction mode, which is related to the overall strategic mission of China's construction industry. SI system is a sustainable development system formed in the development process of housing industrialization. It separates the building Skeleton and building Infill, and realizes the standardized production of components. The building with SI system has the characteristics of long service life, energy saving and environmental protection, fast construction speed, variable house layout and so on. Though it is hard to separate the Skeleton from the Infill and construct respectively, the idea of SI system can be tried to use in engineering measurement and valuation of housing industrialization: it should separate the Skeleton from the Infill, and then lists items and values respectively.

**Table 1.** The comparison on the cost between industrialized building and traditional building.

Name of Cost	Industrialized Building (the symbol * means it is different from the traditional building)	Traditional building	Notes
1.Engineering cost	1.1 Acquisition expenses of the equipment and apparatus	1.1 Acquisition expenses of the equipment and apparatus	Acquisition expenses of the elevator, central air-conditioning.
	*1.2 Acquisition expenses of prefabricate and parts		Prefabricates and fillers such as nonbearing wall, kitchen, bathroom, storeroom, integrated system of equipment and pipes are produced in factory and transported to the spot to be assembled through logistics.
	*1.3 Civil and erection cost	1.2 Civil and erection cost	Narrow project cost, mainly including the engineering cost of support system, the engineering cost and measure cost of the filled system, and other project cost, fees, and taxes.
2. Other fees for engineering construction	2.1 Fees for construction land	2.1 Fees for construction land	Land-transferring fees, removal compensation and so on. Beijing, Shenzhen and other places have introduced preferential land policies about industrialized buildings.
	2.2 Fees for feasibility research report and geological exploration	2.2 Fees for feasibility research report and geological exploration	Consulting fees for consultation units.
	*2.3 Designing fees for supporting system and filler system	2.3 Designing fees	The supporting system (body of structures, bearing carriers, and public parts) has universality as the designing subject of the first stage; the filler system meets the individual requirements of clients as the deepened designing subject.
	*2.4 Integrated agile general and administrative fees	2.4 Management fees for construction(management expenses of construction unit, main contractor management expenses, cost of superintendence, fees for the quality supervision)	The whole process for processing industrialized buildings needs integrated agile resource integrator, concerns with a long industrial chain, including the early financing, land acquisition, calling for bid and bidding, product designing, sales, procurement of material, production equipment and parts, site operation, assembling, and after-sales service, etc,. It is suggested to outsource the non-core parts and lay emphasis on the control over the design, marketing, and integrated management.
	*2.5 Fees for product design and development	2.5 Research and experiment expenses	In the early period of industrialized building, many parts and technologies are introduced from the foreign countries. With the extension of new technologies, the imported parts gradually transit into domestic parts so the research and development expenses tend to decline.
	2.6 Fees for site preparation and temporary facilities	2.6 Fees for site preparation and temporary facilities	The wet construction in the industrialized building construction site declines a lot. The difficulty of first party to manage in the construction site decreases so fees of this item tend to decline.

	*2.7 Maintenance Funds	2.7 Insurance expenses of the project(not including the insurance which has been listed into the management fees of the engineering enterprise)	The maintenance funds should include the management fees, maintenance fees, and the fees for changing the filler in public parts after the construction products being used. The life cycle of the filler varies from 5 to 30 years. Suppose the life of industrialized building is 50 years, the filler should be changed for once at least.
	2.8 Fees for environmental assessment	2.8 Fees for environmental assessment	There are little wet constructions in industrialized buildings, which responds to the principle of “4 saving 1 environment protected”, meeting the requirements of green environmental protection buildings
	*2.9 Government review and approval fees	2.9 Government review and approval fees(project application fees and civil air defense fees in different places)	The traditional government review and approval fees for construction mainly includes the backup fees of infrastructures, fees for quality supervision of project, fees for the construction of civil defense fees in different places. Government should give favors in the early period of industrialized buildings. Till June, 2015, there were more than 30 provinces and cities introduced the supportive policies for industrialization. Beijing and Shenzhen have connected the favor with the reward of the building area
	*2.10 The guide fees for introduced technologies	2.10 Fees for introducing technology and apparatus and other fees	The fees for industrialized technology and parts being introduced from the foreign countries are not included in the acquisition expenses of parts, such as the expenses for the buyer personnel to study abroad.
3. Budget reserve	3.1 Basic budget reserve	3.1 Basic budget reserve	The change of the industrialized construction sites decrease and the basic budget reserve will decrease too.
	3.2 Budget reserve for increasing price	3.2 Budget reserve for increasing price	The industrialized construction period shortens, and the budget reserve for increasing price will decrease.
4. Interest			The industrialized construction period shortens so the interest will decrease.

### 3 Project cost constitution of housing industrialization

#### 3.1 Constitution of traditional construction project cost

The traditional project cost is divided into the broad sense and narrow sense. In the broad sense, the project cost is standing on the angle of the construction side or the investment side. It includes all expense generated in the decision-making stage from the generation of the project conception to set up the project, the implementation phase from design, bidding and tendering, construction to final acceptance of construction, and the operational use phase. It is called the fixed assets investment of construction project. In the narrow sense, it is standing in the perspective of project transactions. The contract price at the stage of bidding and tendering, the construction and installation fee at the construction stage and the settlement price are the manifestation modes of the project cost in the narrow sense. Due to the long industry chain of housing industrialization, it is incomplete to only stand on the angle of the transaction part or take the construction price at any stage into consideration. From the perspective of resource integration, the paper analyzes the total fixed assets investment of housing industrialization.

#### 3.2 Constitution of Housing industrialization Project Cost

From the angle of construction site, it can be found that the wet construction work on site of housing industrialization reduces while the assembling process, transportation and lifting workload increase; during the life cycle, the Infill system needs one or many replacements; the parts module installation in the kitchen and bathroom replaces the tedious site construction process and so on. From the entire development process, the development mode of housing industrialization is summarized as the preparation of specification---technology research and development---products design--marketing promotion---the second design---production--transportation logistics---installation and after sales service and so on. These unique process flows and operation modes of housing industrialization bring greater impact to the constitution and valuation ideas of traditional architecture project cost. In order to build a suitable valuation mode of housing industrialization and lay a good foundation for the promotion of housing industrialization, the paper tries to analyze the constitution of the housing industrialization project cost and compare with the traditional architecture project cost. Please see Table 1.

### 4 Discussion the effect of the project cost on industrialization mode

From Table 1, it can be seen that compared with the traditional architecture, the project cost under the industrialization mode has the following characteristics:

- (1) The purchase cost of prefabricated component and the parts is the biggest price difference between housing

industrialization and traditional architecture. The fee of investing and building a plant is huge, it may cost the manufacturing enterprises of prefabricated component and parts about 200-400 million yuan [6]. The ex works price of prefabricated component and parts depends on the factory output and quantity of service projects. The service items are limited in the early stage of industrialization. The transportation fee depends on the distance from the factory to designated location at the construction site. Due to the large size of prefabricated component and parts, the purchase cost is usually high.

(2) The change of valuation thinking of construction and installation cost. According to the specialty, the valuation thinking of traditional construction and installation fee is divided into architecture engineering, decoration engineering and installation engineering and so on. After introducing the SI system of housing industrialization, it calculates based on the construction fee of Skeleton and Infill. List items belonged to the decoration engineering, installation engineering and non bearing architecture engineering will translate into the form of prefabricated component, parts or parts set, and then bring into the construction fee of Infill. Due to the combination of several construction procedures, and the use of massive finished and semi-finished products, the process of measurement and valuation of construction and installation fee can be simplified.

(3) The labor cost reduces but the machinery costs increases in the construction and installation fee. During the housing industrialization, the workload of cast-in-place concrete has been reduce greatly, so the labor costs and material costs of Skeleton template have been decrease greatly. The application of plant-prefabrication can improve the building quality, and it is good for energy saving and environmental protection. At the same time, it increases the fee of plant-prefabrication, mechanical service charges of field lifting and assembling. However, in the recent years, the labor cost in China rises sharply. In the long run, the labor cost saving has more advantages than the machinery installation fee in the field.

(4) The reserve ratio of other maintenance fee in the engineering construction will increase largely. In the SI system of industrialization, the life expectancy of Infill system is about 5-30 years, so it needs to be replaced or repaired at that time. The replace fee of internal filling parts can be suffered by the user, while the replace fee of the public part and filling parts of external wall should be included in the expenditure of the project cost in the broad sense. As far which expenditure should be included, it should wait for confirmation. In order to avoid developers pass the buck, it can establish the special maintenance fund or transfer the risk in the form of purchasing insurance.

## **5 Suggestions of the project cost development under the industrialization mode**

The development and promotion of housing industrialization is in accord with the idea of sustainable development and green building in China. Professor Bao

Jiasheng ever put forward that "Architecture is not just the solidification of music; it should be a dynamic and sustainable development space form." The construction project cost should cooperate with the promotion of industrialization actively:

(1) Establish valuation basis suitable for the construction engineering fee of housing industrialization. The current 2013 code for valuation with bill was prepared for the traditional architecture which lacks the corresponding list items and measure programs of parts and prefabricated component. The code is revised every five years, so it should take the projects of housing industrialization into consideration and make an adjustment of the division of the original branch and sub-item projects. The sales tax of parts and prefabricated component had been paid when it sold; the counting base of fees and taxes is suggested to deduct this part of the cost in order to avoid repeat counting. The clear scope definition of construction project cost and suitable valuation basis can provide the uniform specification and platform for the accurate accounting and comparison of the project cost between housing industrialization and traditional architecture.

(2) Cost personnel should keep pace with the times to study industrialization knowledge and BIM technology. There are large differences of the operation mode and the process flow of the field between the industrialization and traditional architecture, so cost personnel should learn its construction process and operation mode in advance. The core technology of BIM is a huge database formed by the 3D model. Its information can be used to not only prepare the project cost, but also manage the whole process valuation. These characteristics are fit in with the management model which has the long industry chain of housing industrialization, many participating enterprises and needs integration. With the development of computer technology, BIM will become the hot sharing model between the designer, constructor, and cost personnel in the architectural industry. Currently, the cost calculation software widely used in China is mainly based on the development of 2D platform; the traditional cost method is based on the calculation of construction process; the 3D dynamic of BIM makes models based on the building structure function. Whether it exports the BIM model to external software or uses the BIM as the calculation platform directly, it will bring challenge to the traditional valuation. Housing industrialization and BIM technology will bring great change to the architectural industry in China.

(3) The working emphasis of the cost consulting company and cost personnel should transfer to the active dynamic control from the passive calculation. In the traditional valuation work, it spends a lot of time and efforts to contrast the calculation measurement and control measurement of drawings, and most of them are doing the job passively. Under the industrialization mode, the use of most prefabricated components and parts and BIM technology lead to the simplification of calculation and valuation process, and some works even hand over to the software. Cost personnel can make more time to analyze cost indexes initiatively, actively control factors which may cause the increase of the project cost, treat the change and claimant in time which affects the project

cost, make preparation for settlement and final accounts and so on in order to realize the transformation from the counter of the project cost to the cost manager.

## 6 Conclusions

The paper makes definition and comparison of the constitution of the project cost of housing industrialization in the broad sense. Due to the limited experience, the frame structure of the project cost refers to the current valuation method. Though it doesn't make a quantitative index analysis by combining with specific construction projects, it makes a qualitative analysis of the constitution and characteristics of the project cost in the broad sense. It offers reference for the accurate calculation of the project cost of housing industrialization and provides development suggestions.

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