The Construction of the Whole Life Cycle Model of Industrialized House

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Abstract. Differ from the traditional life cycle definition, process activities of industrialized housing products full life cycle is redefined, each part of the specific activities is analyzed in detail, the whole life cycle model is full built, which is an important basic research. The paper emphasizes and points out the concept of deepening process in the model, analyses the reason from the lack of in-depth program, sums up the specific implementation technology to support in-depth program.

Introduction

Modernization of housing industry is paying careful attention to whole industrial chain, system organization and process of development in whole lifecycle which contains production and operating activities of the relevant units of planning design, investment and financing, development, the production of parts, building construction, operation and management, transformation and renovation, reuse and so on. Therefore, modernization of housing industry is neither a single refers to a link evaluation of the development, also is not the progress and application of a certain technology. The research on modernization of housing industry is must put in a full life to considerate.

Organization of the Text

Industrialized housing product research starts from analysis of the owner needs which not only provide project target but also guide modular design process. Owner's demand for residential product throughout the entire life cycle is from product feasibility analysis to product research, structural experiment, factory manufacture, site-assembled, performance testing, housing delivery,

![Diagram](image)

**Figure 1.** The Whole Life Cycle Model of Industrialized House.
operating recycling guided by owners. The whole lifecycle gather land development, new product decision, product research, technology research, technology collaboration, industrial production, transport hoisting, mechanized construction, structural test, performance test, delivery, operation maintenance in integral whole (as shown in Figure 1).

1. Project decisions of residential product

The main work includes project feasibility study, project evaluation and project decision. The stage emphatically resolves the necessity of project investment, the feasibility and the reason of investment, when to invest and how to implement. Product planning is the most important for investors, because it plays a decisive role in long-term economic benefits and investment direction.

2. The development stage

Product development stage is the important stage in whole life cycle of residential product. This phase includes the concept plan selection, system design (split design), deepening design, engineering design, small-scale production and preliminary construction experiment and preliminary performance test.

Complex product development stage is significantly characterized by a large number of information exchange and transmission between design activities. A lot of research and development activities are invisible, varied and unpredictable. It is not only difficult to determine development time, at the same time, the information of product research and development is often repeated and flowing\(^1\). At this stage more professionals need to participate in, knowledge and skills are more diverse.

In the initial stage of product design, the initial architectural design sketches is provided to the owner, Usually two or three sets of product solutions is prepared for the owner to choose, draft plan contains the project intention, the schematic diagram of products, product conceptual model and the general function layout and building economic and technical index.

![Figure 2: Plan Split Graph of Precast Façade.](image)

System design phase is based on WBS work breakdown structure method to decompose module hierarchy in industrialized housing system. Based on the analysis of which, content of the system design mainly includes that the design method of the industrialized housing is confirmed, the object is regard as a whole system, which is decomposed into several modules. Design goal, the function and relationship of each module is determined and each module can be separately designed, manufactured and built, which determine the management system and control mode of module system (as shown in Figure 2).

The phase to deepen the design: Once the systemic design scheme is passed, the new product will turn to the phase to deepen the design. This stage needs to achieve mastery through a
comprehensive variety of professional knowledge, needs close cooperation and work together to complete the systematic design of engineering from different professional background of professional. The basic activity of the phase is the optimization of industrialized housing product design and the deepening of the prefabricated design and technology research and development of new products. Prefabricated deepened design includes installation node drawings, reinforcement drawing and components processing detail that need more professional Design. Installation node drawings contain about member sizes, volume, weight, embedded parts of hoisting, embedded parts of electric and plumbing holes. For example, according to the electric drawings and architectural plane drawings, reserved hole of electric, air channel, smoke flue and lamps junction box is designed deeply.

Reserved holes on kinds of prefabricated slab are labeled, the geometric shape, position and size of holes are determined. Reinforcement drawing includes schedule of the steel, sleeve spool type and so on (as shown in Figure 3). At the same time, the deepening design of prefabricated parts still includes stress calculation analysis of embedded parts and components.

The core of the phase is circulation of “design-build-test” as same as the core of the product engineering. If the design can't reflect expected performance characteristics, engineers should be seeking to make up the difference through design improvements. The final design of the products is marked by meeting the technical requirements.

Now our usual residential design can't meet the requirements of industrialization, there is a great gap between usual design and industrialization. At the present stage, although some large construction enterprises try deepening design, it is difficult to take out a complete set of design drawings. They still according to the needs of the market and factory constantly modify the design for non-standard production. On the other hand, architectural design drawings convert to modular construction design which means the assembly build drawings still spend a long time, for example, Bhouse enterprise still need to take half a year to convert design drawings.

In addition, there are actually no effective measures to support the deepening program implementation. The research on industrialized housing new product technology is the necessary stage of development of the industrialization of residential product. Given the lack of the talents and advanced equipment of the industrialization of China's current construction, the cultivation of the technical personnel and advanced industrial residential technology development are particularly important. To implement a design into a component diagram, component diagram into actual residential part again need a supporting technology research and development of new products held by technical unit. Technology research and development mainly includes the following contents:

Figure 3. Details Drawing of Reinforcing Bars of Interior Board.
a. Structure technique

Prefabricated concrete structure is main structure form of the industrialized housing. The key of structure technology is node processing technology. The cost of current node processing is high, but its effect is general, we should explore the node connection technology with appropriate cost and good effect. And the application scope of prefabricated concrete structure is outside range of existing specifications, the research cost is huge, there is no guarantee that it has a good effect. Technological route of prefabricated construction at the present stage is that level components (such as beam, column, floor, etc.) are comopised, the vertical component (shear walls, etc.) is in situ, peripheral protection components (cladding) are fixed.

b. Fabricated construction technique

Construction process is the link that can reflect industrialization technology advantage. Prefabricated construction technology of reinforced concrete structures are mainly: constructional informational management, hoisting technology of large prefabricated unit, node reinforcement processing, etc. General construction equipment has gap with prefabricated construction requirements. To develop a special high precision and large range of adjustable speed of the crane, to develop all kinds of lifting jig which is applicable to different types of fabricated part, to develop casting fittings and support equipment to facilitate rapid installation, to develop fixed equipment to facilitate rapid installation and fixation in transportation vehicles, to introduce handheld electric equipment to facilitate workers on-site installation and removal of homework are necessary.

![Figure 4. Prefabricated Production Technology.](image)

c. Prefabricated production technology

Prefabricated production technology is an important part in construction of industrialization which is beneficial to the formation of industry, is also a weak link. Enterprise is too little, and the production level is generally low. New production equipment with independent property rights is badly in need, whose operation is simple, less with artificial, stable quality, high yield and suitable price. Because precast structure adopts the factory production mode, standard production equipment and production technology can guarantee the stability and reliability of quality of the components (as shown in Figure 4).

In addition to developing new production equipment, according to the mode of production of PC
components and mold processing principle, mold is designed in accordance with production requirements. Mold design includes the composition and parts design for different part of the mold such as internal and external wall panel die design, composite plate mold design and stairs mold design, mold development and production technology is one of the key activities.

d. The residential structure experiment technology of component parts

Owing to the adoption of new technology, it is necessary to construct new technology experiment. The accurate control of products and precision parts on the quality of the finished product is especially important.

In the process of industrialized housing construction, the choice of materials and test are more strict, the productive process is more powerful to control. To effectively control the precision of the product can greatly improve the quality of the finished product. At the scene, in order to ensure construction quality, construction personnel will do a variety of experimental tests on the material and framework components, for example, Vanke select and test new materials in the exploration and practice of industrialized housing which contains slump, pull-out test of external wall, ballast test, etc. Experiment proves that the reliability of the product quality.

Engineering phase: shift from the traditional construction design to assembly process design. Industrialization required parts are fast transported to the site for the rapid assembly, whose premises are to turn traditional construction plan into the assembly diagram for formation of specialized engineering design.

Small-scale production, construction phase: in this phase, individual parts of the initial processing and testing and basic components, building components and building elements have been put together as a system put to test in a factory. In small-scale production, less number of products should be produced so that test new or improved production process to ensure that production capacity. In this moment, product design, deepening design activities, tools and machinery, parts, assembly procedure, engineers, operators and industrial workers of the whole system integrate together.

Component structural testing: new product development process through experiments unceasingly validate the concept and ideas of new technology, new technology can be adopted in order to ensure the stability of the product structure, the experiment content mainly contains calculation and analysis of the stress of fabricated part and embedded part, then take samples for testing.

Component performance test: test content contains part, material fireproof performance test, part, material heat preservation and sound insulation performance testing, part, material moisture proof performance test, etc. Component performance test is the analysis and evaluation of the physical test to construction component subsystem.

3. Industrial manufacturing stage

This stage is assembly stages in factory for related components production. Industrial manufacturing really implement and put into production on the basis of the quality, value stream is given priority to logistics. The factory starts standard parts production according to distributed information from database at the research and development stage, assembles parts by assembly sample files.
4. Construction testing phase

Structure test information feedback of residential product: the adoption of new technologies and new products which are tested in the factory and meet the design standards and then shipped to the final assembly on site. The new design and new ideas used in the design in the process of practical operation sometimes can’t necessarily be implemented in accordance with the original design idea. This is because there are many unpredictable factors in the process of actual operation such as implementation schedule, or operative difficulty or mechanical aspects. So the new ideas need constantly experiment to prove the through feasibility constantly experiment, then are used to the actual project before the implementation. Build testing is mainly focused on stress test for prefabricated parts and embedded parts.

5. Lifting transportation phase

Lifting transportation phase achieve process of parts assembly, parts distribution, parts lifting, which is the intermediate links to realize the factory building and field assembly.

6. The final assembly stage

Mechanization construction has broken the traditional construction way and changes wet homework to dry homework which not only saves water but also changes the traditional working environment. The core of industrialized housing assembly task is to assemble the module on site, optimize assembly process, change the original serial working mode, improve work efficiency, shorten the construction period.

7. Performance test phase

Residential product performance test information shows that our country construction related energy consumption accounts for about 46.7% of the total energy consumption [2] now. By 2030 greenhouse gases produced by construction will constitute 24% of the whole society [3]. So product performance testing for the industrialization of the new housing is crucial. The performance test data can clearly reflect that the energy consumption of new technology is reaching the standard or not. The performance test can also provide specific data to better realize the technology innovation and performance improvement in the next step. The performance test is necessary in the low energy consumption residential product whole life cycle management model.

8. Product available for use

Industrialized housing are sold to the buyers after the acceptance of products by the owner organization. The housing product on sale are primary finished or semi-finished products. The real estate development enterprises sell the commodity house to the buyer after completion acceptance or sell the commodity house under construction to purchasers. The buyer may pay the deposit or price.

9. Operation and maintenance

Operation and maintenance are important stages in whole life cycle of industrialized housing products. Facility operation and maintenance consist of facilities management, equipment operation and maintenance of the building (Eastman, C.M. 1988) [4]. The housing space, architectural structure, environmental planning, equipment operation management need the feedback information
at maintenance phase to constantly improve the details of product, and it is a long-term process of accumulation.

References


