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Research on Improvement of Design Efficiency of Prefabricated Building Mold under Standardized Process

Meina Zhao[a], Xinyao Huang[b,*]

Jiangxi University of Applied Science, Nanchang, China
[a]599370822@qq.com, [b]569370812@qq.com
[*]Corresponding author

Abstract: *The mold design of prefabricated building structural components is an important part of the production of prefabricated components. Traditional molds can only be produced with corresponding components, and the repeated utilization rate is low, resulting in the high cost of prefabricated buildings. important bottleneck. In order to optimize the design management and control to give full play to the integrated advantages of prefabricated building design, production and assembly, this paper systematically analyzes the feedback mechanism between the target requirement elements, functional structural elements and professional design elements of prefabricated components; The scope and feedback quality are used as optimization objective functions to establish a QFD-DSM model for the design and control of prefabricated components. After optimization through this method, the information interaction between the design elements of prefabricated components is stronger, the rework iteration is effectively reduced, the design task sequence is more scientific, and the design control effect of prefabricated components is significantly improved.*

Keywords: *Standard process, Prefabricated building mold, Prefabricated components, Design control, Integrated system*

1. Introduction

The components of construction industrialized parts are produced by factory molds. Due to their various forms, a large number of molds need to be designed and manufactured. Chinese construction industrialization component molds started late, and most of the construction mold enterprises were transferred from ordinary mold enterprises, and the technical level was low. At present, there are mainly the following problems in the mold of building industrial components. 1) Unreasonable structure and large quality Due to the large size of the components of the industrialized construction parts, the mold size, self-heavy and large deformation are caused, which seriously affects the quality and accuracy of the components of the industrialized construction parts. 2) Easy to rust because both cement and water are corrosive, the prefabricated components need to be cured after pouring, and the mold is easy to rust. 3) Low degree of standardization and poor versatility Due to the different technical standards of construction enterprises, the standardization degree of industrialized parts and components of construction is low. In view of this, this paper jointly uses the QFD and DSM methods to establish a design control model for the prefabricated components of prefabricated buildings [1]. Using the QFD method to analyze the correlation between the control elements affecting the design of prefabricated components from the three dimensions of the prefabricated building prefabricated components target requirement elements, functional structural elements and professional design elements layer by layer; analyze the relationship between information input and output between different design elements, build a DSM matrix and analyze rework effects between different design elements.

2. Mold design stage

The mold design of building components is very important, which directly affects the manufacturing cost and service life of the entire component. Therefore, the stiffness of the mold must first be considered when designing the mold. If the stiffness is not enough, the number of mold turnovers will be greatly reduced. This will result in high secondary additional mold costs or mold maintenance costs, which may even greatly affect the progress of the project [2]. At the same time, mold defects may occur due to

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insufficient mold rigidity, which may affect the quality of the components produced. Secondly, in the design of the mold, it is necessary to consider the versatility of the mold, that is, to increase the reuse rate of the mold, which requires consideration of the continuity of the project in the design process, so that the mold can be put into operation after a project is completed. After the use of the next project or small rectification, it can be put into use in subsequent projects, to avoid the situation that the mold cannot be connected with the subsequent projects and discarded after a single project is used. Finally, in the mold design process, the production process of building components also needs to be considered, otherwise the production efficiency will be greatly reduced. On the premise of mold rigidity and precision, the number and time of mold assembly and mold removal processes are reduced, and production efficiency is improved, as shown in Figure 1.

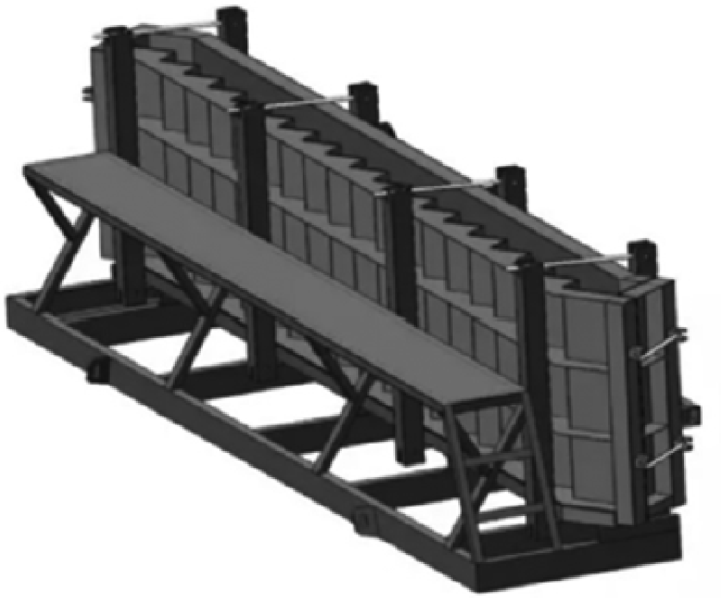

Figure 1: 3D drawing of vertical stair mold

3. Design of PC component family library management system

3.1. Functional Module Design of Family Library Management System

The PC component family library management system mainly has four main functions: system management, family component calling, family component storage, and database. The PC component family library management system has a total of 4 layers of technical architecture: user layer, function layer, processing layer and data layer. The user layer, also known as the top layer, is used to display and receive various kinds of information and provide users with an interactive interface [3]. Various users who use the PC component family library management system can exchange data with the function layer through the network to complete the required requirements. Work. Based on the user requirements analyzed above, the specific functions of the PC component family library management system are determined according to the feasibility boundary of technology and resources to form a functional layer. The family library management system mainly includes system management, user management, family component calling and family component uploading. The information generated when the user performs relevant functional operations will enter the processing layer, and the user instructions will be converted into machine-recognized language for information transmission. After the user's instruction is processed, the PC component family library management system will enter the data layer. Through the connection with the database, the database language is executed, and commands such as adding, deleting, modifying, and checking the information in the database are realized. The technical architecture diagram of the PC component family library management system is shown in Figure 2 (the picture is quoted from i.MX 8M Nano Family - Arm® Cortex®-A53, Cortex-M7).

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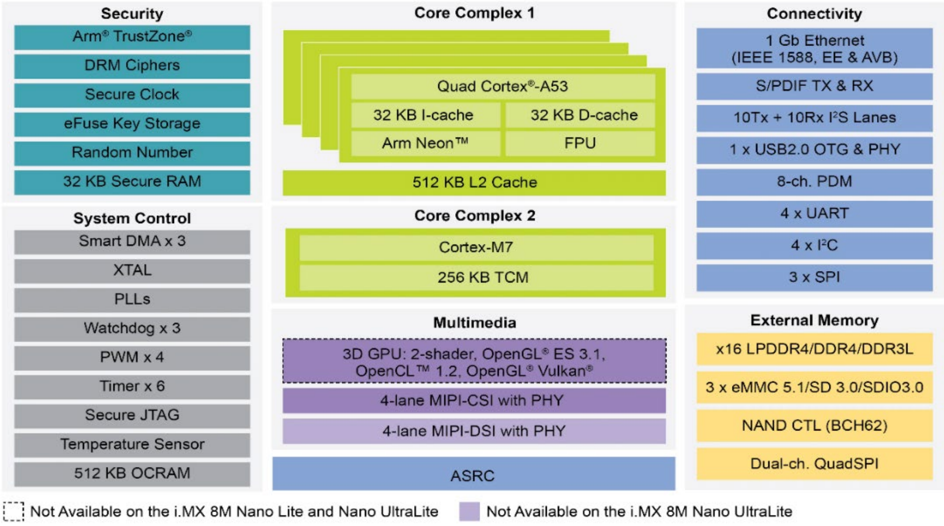

Figure 2: Technical architecture of PC component family library management system

3.2. Sequence diagram design of family library management system

The sequence diagram of the PC component family library management system, also known as sequence diagram and sequence diagram, is a UML (Unified Modeling Language) interaction diagram, which is used to describe the dynamic process of sending information between objects in time order. This section designs the sequence diagrams in system management, family component calling, and family library management in the PC component family library management system [4]. The administrator of the PC component family library management system can add, delete, and modify the basic information of ordinary users, and can also add, delete, and modify the basic information of the PC component family library management system. The sequence diagram for the management of the PC component family library management system is shown in Figure 3 (the picture is quoted from Sequence diagram for library management system: a detailed guide).

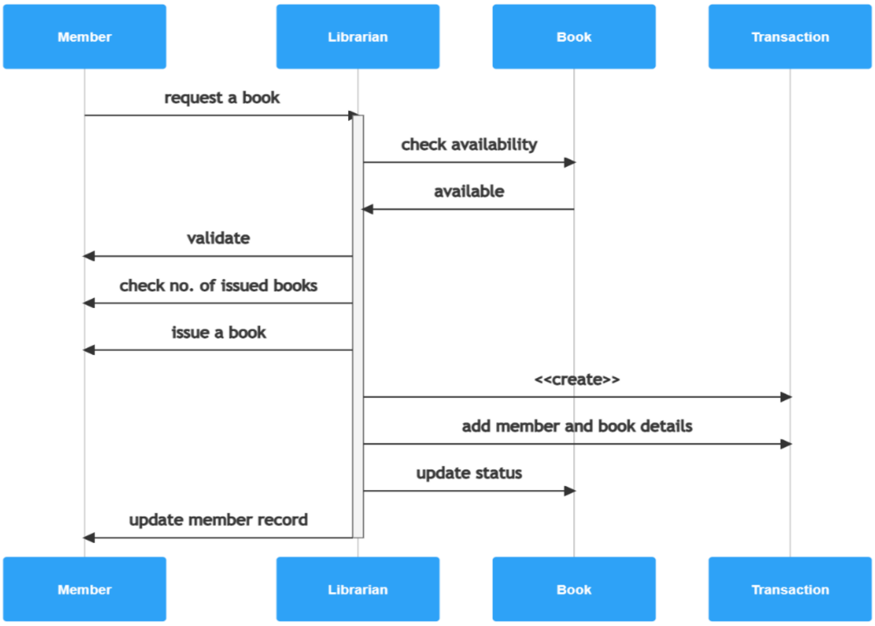

Figure 3: PC component family library management system management sequence diagram

3.3. Functional structural elements

The production process of prefabricated components is different from general products, and its integration, fluidity and coordination characteristics make the whole production process more complicated, which is not conducive to management and control. In the actual production process, any problems in the production of prefabricated components will adversely affect the function of the prefabricated components, and will bring more serious safety problems to the later transportation and construction links [5]. On the basis of clarifying the target requirement elements, according to the key nodes in the production, transportation and assembly process of prefabricated building prefabricated components, determine the functional and structural elements that affect prefabricated components as production process flow, steel bar binding, connection sleeve positioning, mold assembly and Inspection, installation of embedded parts, rebar entry, concrete pouring and curing, demolding, raw materials, dimensions, types of components, storage and transportation, and hoisting.

4. Model building

By analyzing the design control elements of prefabricated components, the target requirement element-functional structure element QFD matrix and the functional structure element-professional design element QFD matrix are respectively constructed, and the DSM matrix of professional design elements is calculated to establish the QFD-DSM model. On this basis, the genetic algorithm is used to reorganize the DSM matrix to obtain the optimal task order for the design of prefabricated components. The design and control model of prefabricated building components established in this paper is shown in Figure 4 (the picture is quoted from A PRODUCT PLANNING FRAMEWORK FOR MASS-CUSTOMISATION IN CONSTRUCTION).

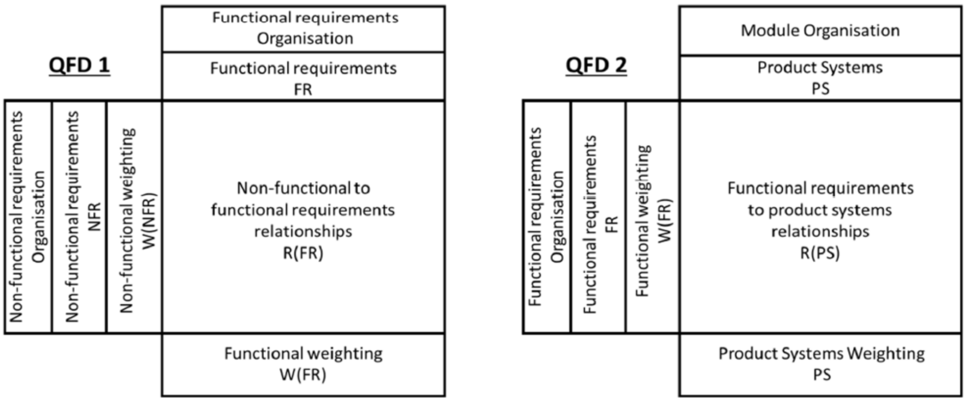

Figure 4: Design and control model of prefabricated components based on QFD and DSM

Quality Function Deployment (QFD) is a mapping method in the design stage, which reflects the dependencies between elements of different dimensions by building a QFD matrix. First, the target requirements elements of the prefabricated components are mapped to the functional structural elements of the prefabricated components, and then the functional structure is mapped to different professional design links, so as to clarify the control goals and coordinate the design work [6]. The Design Structure Matrix (DSM) is suitable for the identification, analysis and management of complex systems. The DSM matrix can clearly describe the feedback and rework iteration characteristics between different design tasks. Its row and column elements represent the professional design elements of prefabricated components. The elements on the diagonal line represent the design elements themselves, and the elements on the off-diagonal line represent different design activities. information interaction between them. Establish the target requirement element-functional structure element QFD matrix, realize the mapping of the prefabricated component target requirement functional structure element, use the rough number theory to determine the dependency between the target requirement element and the functional structural element, and calculate the importance of the functional structural element of the prefabricated component. for:

$$\beta_y = \Sigma_{x=1}^{X} \alpha_x QFD(x, y) \tag{1}$$

In the formula, β_y is the importance of the functional structure element α_x is the importance of the target requirement element. $QFD(x, y)$ is the dependency between the target requirement element and the functional structure element. X is the number of elements required by the target. y is the serial number of the functional structural element of the prefabricated component [7]. Establish a functional structure element-professional design element QFD matrix, realize the mapping of prefabricated

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component functional structure elements to professional design elements, use rough number theory to determine the degree of dependence between functional structural elements and professional design elements, and calculate the importance of prefabricated component design elements the formula is:

$$\gamma_z = \Sigma_{y=1}^{Y} \beta_y QFD(y,z) \tag{2}$$

In the formula, γ_z is the importance of professional design elements $QFD(y,z)$ is the degree of dependence between functional structural elements and professional design elements; Y is the number of functional structural elements; z is the serial number of professional design elements. Each functional structural element of a prefabricated component is formed by the interaction of one or more professional design elements [8]. According to the functional structural element-design element QFD matrix, the degree of dependence between professional design elements and functional structural elements and the importance of technical characteristics Calculate the autocorrelation of professional design elements, that is, the design element DSM matrix. The calculation formula is:

$$DSM(i,j) = \Sigma_{y=1}^{Y} \beta_y I_{j\to i} QFD(y,j) / \Sigma_{y=1}^{Y} \beta_y QFD(y,j) \tag{3}$$

In the formula: $I_{j\to i}$ indicates whether the functional structure element y has a constraint relationship on the design elements I and j, if there is no constraint relationship, then $I_{j\to i}$ = 0, if there is a constraint relationship, then $I_{j\to i}$ = 1.

5. Case Analysis

The static load test takes a prefabricated PC component staircase as an example to analyze the mechanical performance of the component. First, compare the theoretical value under the measured load with the deformation value to confirm whether the floor slab can meet the standard of the design load and the total state of the final use. In the test results, the mechanical properties of the test PC member structure should be confirmed according to the measurement of the deformation, storage capacity and crack width of the PC member. First of all, according to the strength characteristics and test requirements of the component, set 4 deformation measurement points at the center of both ends of the component, and use a Bluetooth 4.0 remote adapter. In order to monitor the deformation of the component under different loads in real time, the top and bottom of the stair component are respectively the purpose of placing a monitor is to obtain information such as cracks caused by stress during the connection process in real time, so that the component connection can be completed on the basis of ensuring that the cracks do not reach the limit bearing value. The image of the monitoring point layout is shown in Figure 5 above (the picture is quoted from Enhancement of gallium phase change heat transfer by copper foam and ultrasonic vibration).

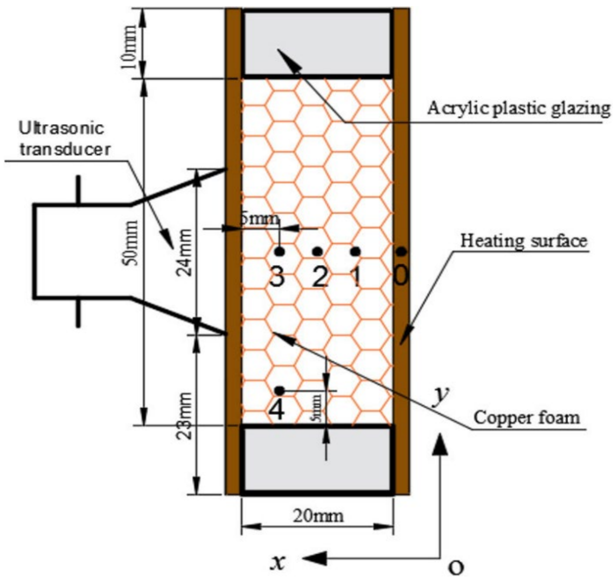

Figure 5: Schematic diagram of measuring point layout

The detailed analysis of the mechanical properties of the components is shown in Table 1. The results of the test explain: 1) When the test load is 9.74kn (load factor is 1.20), the measured bending deflection of the component is 7.58mm < 57.60mm (bearing capacity mark); bending deflection: L/50=2880/50=57.6mm (L stands for member length). 2) The maximum crack width measured should be less than 1.5mm (a sign of bearing capacity). 3) Under the load effect of the loading coefficients at all levels, the member does not have the characteristics of the bearing capacity mark.

Table 1: Force characteristic analysis table

Force type	Bearing capacity sign	Load factor	Force loading value	Experimental results
Tension, compression, bending force	Bending deflection up to one-fifth of the span	1.18	33.55	7.58<57.60mm
	The crack width of the main tension part reaches 1.5 mm	1.18	33.55	The maximum crack width of the component is 0.32 mm
	Fracture at the main tensile force of the member	1.45	46.71	none
	Bending under pressure	1.20	35.85	none
	Compression member failure	1.52	56.73	none
Shear force	Member abdominal slit width 1.5mm	1.39	42.44	The maximum crack width of the component is 0.56 mm
	Shear failure occurs	1.39	42.44	none
	Cross-section crack failure	1.45	46.71	none
	Component section broken	1.45	46.71	none
Twist strength	Oblique abdominal cleft up to 1.5 mm	1.34	38.56	The maximum crack width of the component is 0.42 mm
Partial pressure	Component indentation	1.35	39.12	none
	cracked edge	1.48	49.77	none
Rebar Anchor Connection	Component anchor failure	1.48	49.77	none
	Force transmission failure	1.50	54.31	none
	Interruption of force transmission	1.55	59.46	none

6. Conclusion

This paper introduces the concept of family and uses Revit API combined with the software development platform to provide a family library management system for prefabricated components for users such as design units and component manufacturers. The system realizes the functions of systematic management, modification, application and maintenance according to the types of components. The mold design and production process of PC components are the key areas of modern construction technology. In the production process of PC components, from the design of the component production mold to the hoisting of the components after production, the requirements must be strictly followed, so that the produced PC components can meet the architectural design requirements in terms of strength and compression resistance.

Acknowledgments

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