Research on Development Countermeasures of Prefabricated Buildings in Chongqing Based on SWOT Analysis

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Abstract: The development of prefabricated building is a transformation of the traditional construction mode, a new cut-in point for the sustainable development of the construction industry in China. As an important city in the development of the western region, the development and promotion of prefabricated buildings in Chongqing has played an exemplary role for other cities. Therefore, this research provides a certain degree of theoretical exploration and practical application. In this paper, SWOT analysis is used to analyze the advantages, disadvantages, opportunities and challenges of the prefabricated building, and to gain a full understanding of the development conditions of the prefabricated building. On this basis, the paper summarizes the four major constraints on the development of prefabricated building, including policy factors, economic factors, technological factors and industrial factors, and analyzes the weight of these constraints, in view of each restriction factor proposed the corresponding solution countermeasure.

1. Overview
Chongqing, as the window of the cities in southwest China, with a permanent population of about 10 million, is a super-large central city. Currently, Chongqing is at the stage of accelerating the process of urbanization, and the shaping and promotion of its urban brand is particularly crucial, therefore, it is necessary to promote the industrialization level of urban architecture. This paper carries out SWOT analysis on the development of Chongqing prefabricated building (SWOT analysis is an objective method to analyze the advantages, disadvantages, opportunities and challenges of Enterprises), and finds out the main restrictive factors, to put forward countermeasures and suggestions for the development of prefabricated building in Chongqing.

2. SWTO Analysis on the Development of Prefabricated Buildings in Chongqing

2.1 Advantages of developing prefabricated buildings in Chongqing
(1) The policy standard system is basically established. Since the General Office of the State Council issued the Implementation Opinions on Vigorously Developing Prefabricated Buildings in 2016, dozens of prefabricated concrete structure standards and atlases including the Design Regulations for Prefabricated Concrete Residential Building Structures of Chongqing have been issued.

(2) Results of pilot demonstration projects are beginning to show. Chongqing organized and implemented 68 construction industry modernization demonstration projects. He has accumulated engineering experience in precast concrete buildings, precast steel structures and precast steel-concrete composite structures.

(3) Preliminary scale of supporting industry cultivation. The city of Chongqing has taken an active
part in the construction of assembly-type demonstration bases, organized and implemented the construction of five comprehensive pilot areas for the modernization of construction industry at the municipal level and 24 demonstration bases at the municipal level, and successfully introduced leading enterprises such as Xiaogang construction and Yuanda living-and-working prefabricated building in Hangzhou, with an annual output value of 20 billion yuan.

2.2 Problems in the development of prefabricated buildings in Chongqing

(1) The industrial policy support is not strong. Chongqing City currently lacks top-level design and planning for the development of the prefabricated construction industry, and there are still policy obstacles to enterprises entering the park.

(2) The demand for project stimulation is not high. Chongqing is a mountainous city with low demand for prefabricated parts in recent years, making it difficult to provide an effective supply and demand market for the prefabricated building industry.

(3) The industry category is not complete. Prefabricated building is characterized by mass production, large-scale construction, it is inevitable that there will be a single style.

(4) The implementation capacity of the enterprise is not strong, the industrial chain is not perfect enough. At present, the number of prefabricated building enterprises in our city is small, lack of practical experience, lack of leading enterprises, the overall implementation capacity is weak.

2.3 Opportunities Facing Chongqing’s Development of Prefabricated Buildings

(1) Rising labor costs
As the city's labor population shrinks, the rise in labor prices will offset the disadvantages of prefabricated construction costs, and the development of prefabricated buildings ushered in a good opportunity.

(2) Requirements for building energy conservation and emission reduction
In the whole society under the initiative of Energy Conservation and environmental protection, through the implementation of fabricated construction technology to address people's needs in this regard, the construction industry as early as possible to achieve energy conservation and emission reduction goals.

(3) National requirements for residential and construction quality management
With the development of social economy, people's requirements for housing quality have increased, and traditional construction methods are no longer suitable for the future development of the construction industry.

(4) The construction of affordable housing provides opportunities for the development of prefabricated buildings
The government led construction of low income housing in Chongqing provided the prefabricated building with market demand.

2.4 Challenges facing the development of prefabricated buildings in Chongqing

After analyzing the development of prefabricated buildings in Chongqing, it still needs to face the following four challenges:

(1) Sluggish real estate market
At present, the real estate market in Chongqing has a high inventory, and the market has not been able to digest such a large amount of inventory, causing the land market to slump.

(2) Market acceptance of prefabricated buildings is low
In recent years, most commercial buildings have been constructed with cast in place reinforced concrete structures, which has cast doubt on the seismic performance of the prefabricated building and hindered the prefabricated building's propulsion.

(3) The enterprise is not enthusiastic enough to participate
At present, the cost of prefabricated construction is higher than that of traditional cast-in-place construction, and real estate developers are not enthusiastic about participating.
(4) The venue and transportation are restricted

The precast concrete component factory covers a large area and is located in the suburbs, far away from the project site, which increases transportation costs. In addition, there is currently a lack of professional transport vehicles capable of transporting large components in the industry.

The above SWOT analysis of prefabricated buildings shows that the development of Chongqing prefabricated structure system has advantages, disadvantages and opportunities and challenges. Table 1 shows the SWOT analysis table of prefabricated buildings, which lays the foundation for the next step of analyzing the constraints of Chongqing's promotion of prefabricated buildings [3].

Table 1. SWOT analysis matrix for the development of prefabricated buildings in Chongqing

| Advantage | Disadvantage | Challenge |
|-----------|--------------|-----------|
| 1. Policy advantages | 1. Lack of policy norms and standards | 1. The real estate market is sluggish |
| 2. Economic advantage | 2. The problem on how to control the cost | 2. The market has low acceptance of prefabricated buildings |
| 3. Own prefabricated construction enterprises and projects | 3. Insufficient diversification of prefabricated buildings | 3. The enterprise is not enthusiastic enough to participate |
| 4. Modern building industrialization base provides technical support | 4. Imperfect industrial chain | 4. Site and transportation are restricted |
| 5. Technical standards are gradually improved | | |

3. Analysis of Restrictive Factors of Prefabricated Building

Through SWOT analysis of the advantages, disadvantages, opportunities and challenges of prefabricated buildings, combined with other documents to sort out the prefabricated buildings in Chongqing, the four main constraints on the development of prefabricated buildings are summarized. That is, policy norm factors, technological system factors, economic factors and industrial factors. In addition, these four major factors can be divided into 11 small factors. These constraints are scored by experts to score the influencing factors of the prefabricated building, and the weight of each constraint is calculated by the AHP method and sorted to form the prefabricated building constraints analysis table [3].

Taking Beijing, Shanghai, Chongqing, Chengdu, Shenzhen and other places as examples, experts adopted anonymous surveys, ranked according to the importance of indicators, and then using the analytic hierarchy process (AHP method) as the principle, the development constraints of prefabricated buildings in Chongqing have been calibrated.

3.1 Factor analysis

Table 2. Restrictive factors of prefabricated buildings

| Prefabricated building constraints | B1: Policy factors | B2: Technical factors | B3: Economic factors |
|-----------------------------------|-------------------|---------------------|---------------------|
| Lack of a practical standard system C1 | Modulus system is not sound C3 | The production price of prefabricated components is opaque C6 |
| Lack of effective incentive measures C2 | No component recommendation, elimination and certification system C4 has been formed | |
| | The industrialized system has not formed C5 | |
| | | | |
The short-term comprehensive benefits of prefabricated buildings are not significant C7
The economies of scale have not been formed C8

B4: Industrial factors
Separation of design and construction C9
Uncoordinated development of the industrial chain C10
Insufficient application of information technology C11

3.2 Set the scale
Using 5 attributes to scale equally important, slightly important, more important, strongly important, absolutely important. When the scale is high in accuracy, the value between two adjacent attributes is taken to get 9 scales. The 1-9 ratio scaling method is introduced, and 1, 3, 5, 7, and 9 are specified to represent judgments based on experience. Element i is compared with element J: equally important, slightly important, more important, strongly important, absolutely important, and 2, 4, 6, 8 represent the compromise between the above two judgment levels [4].

Table 3. Comparison table of factor importance

| Scale | Definition (comparison factors i and j) |
|-------|-----------------------------------------|
| 1     | Factors i and j are equally important    |
| 3     | Factors i and j are slightly more important |
| 5     | Factors i and j are more important       |
| 7     | Factors i and j are strongly important   |
| 9     | Factors i and j are absolutely important |
| 2, 4, 6, 8 | The median value of two adjacent judgment factors |
| Reciprocal | The comparison of factor i and j gives the judgment matrix aij, then the judgment of factor j compared with i is aji=a1/aij |

Note: aij represents the ratio of relative importance of element i to element j, and has the following relationship:
aij=1/aij; aii=1; i,j=1,2,...,n, the greater the ratio, the higher the importance of element i.

3.3 Construction of judgment matrix

Table 4. Judgment of matrix A-B

| A     | B1  | B2  | B3  | B4  |
|-------|-----|-----|-----|-----|
| B1    | 1   | 3   | 1   | 5   |
| B2    | 1/3 | 1   | 1/3 | 3   |
| B3    | 1   | 3   | 1   | 5   |
| B4    | 1/5 | 1/3 | 1/5 | 1   |

Table 5. Judgment of matrix B1-C

| B1     | C1 | C2  |
|--------|----|-----|
| C1     | 1  | 1/3 |
| C2     | 3  | 1   |

Table 6. Judgment of matrix B2-C

| B2     | C1 | C2  | C3  |
|--------|----|-----|-----|
| C1     | 1  | 3   | 3   |
| C2     | 1/3| 1   | 1   |
| C3     | 1/3| 1   | 1   |
Table 7. Judgment of matrix B3-C

|   | C1  | C2  | C3  |
|---|-----|-----|-----|
| C1 | 1   | 1/4 | 1/6 |
| C2 | 4   | 1   | 1/3 |
| C3 | 6   | 3   | 1   |

Table 8. Judgment of matrix B4-C

|   | C1  | C2  | C3  |
|---|-----|-----|-----|
| C1 | 1   | 3   | 6   |
| C2 | 1/3 | 1   | 4   |
| C3 | 1/6 | 1/4 | 1   |

3.4 Calculation of eigenvalues of each judgment matrix

Feature vector and consistency check:

① Normalize the judgment matrix A by column (that is, the sum of the column elements is 1): \( b_{ij} = \frac{a_{ij}}{\sum a_{ij}} \);

② Sum the normalized matrix by rows: \( c_i = \sum b_{ij} \) (i=1, 2, 3...n)

③ Normalize \( c_i \): get the feature vector \( W = (w_1, w_2, ... w_n)^T \), \( w_i = \frac{c_i}{\sum c_i} \)

④ Find the maximum eigenvalue corresponding to the eigenvector \( w \):

1) Calculate eigenvalues by summation method:

\[
A = \begin{bmatrix}
1 & 3 & 1 & 5 \\
1/3 & 1 & 1/3 & 3 \\
1 & 3 & 1 & 5 \\
1/5 & 1/3 & 1/5 & 1
\end{bmatrix}
\]

2) Sum by line and normalized to obtain \( AW = (0.389 \ 0.513 \ 0.389 \ 0.069)^T \)

3) Calculate the characteristic root:

\( AW_1 = 1*0.389 + 3*0.153 + 1*0.389 + 5*0.069 = 1.582 \). Similarly,

\( AW_2 = 0.619 \)

\( AW_3 = 1.582 \)

\( AW_4 = 0.276 \)

4) Calculate the largest characteristic root:

\( \sum_{i=1}^{n} \frac{A_{wi}}{nw_i} \)

\( \lambda = \frac{4*0.389}{4*0.389} + \frac{4*0.619}{4*0.153} + \frac{4*1.582}{4*0.389} + \frac{4*0.276}{4*0.069} = 4.044 \)

5) Perform the consistency check:

\( C.I. = \frac{\lambda_{max} - n}{n-1} = \frac{4.044 - 4}{4 - 1} = 0.015 \)

Check the average random consistency index of the same order (shown in Table 10) to find that \( R.I. = 0.89 \) (It is generally considered that when CI<0.1 and CR<0.1, the consistency of the judgment matrix is acceptable, otherwise the comparison will be performed again.).
Table 9. Average random consistency indicator

| Order | 3    | 4    | 5    | 6    | 7    | 8    | 9    | 10   | 11   | 12   | 13   | 14   |
|-------|------|------|------|------|------|------|------|------|------|------|------|------|
| RI    | 0.58 | 0.89 | 1.12 | 1.26 | 1.36 | 1.41 | 1.46 | 1.49 | 1.52 | 1.54 | 1.56 | 1.58 |

\[ C.R. = \frac{C.I.}{R.I.} = 0.015 \]
\[ R.I. = 0.89 \]
\[ C.R. = 0.016 < 0.1, \text{ it meets the consistency requirements.} \]

In the same way, the characteristic root, characteristic vector, and consistency test of the remaining judgment matrix can be obtained.

It is judged that the matrix B1-C is a second-order matrix, and the one-time test does not need to be performed.

\[ W = (0.25 \ 0.75)^T \]

Judgment matrix B2-C:
\[ W = (0.6 \ 0.2 \ 0.2)^T, \lambda_{max} = 3, \quad C.R. = 0 \]

Judgment matrix B4-C:
\[ W = (0.087 \ 0.274 \ 0.639)^T, \lambda_{max} = 3.054, \quad C.R. = 0.047 \]

3.5 Total rank order
After obtaining the relative importance of the elements at the same level, the overall importance of the elements at all levels can be calculated from top to bottom. Suppose there are m elements c1, c2, ..., cm in the second level, and their importance to the total value is w1, w2, ..., wm; its next level three has a total of n elements p1, p2, ..., pn. Let the importance (weight) of the element pi to cj be vij, then the comprehensive importance of the three-level element pi is:

\[ W_i = \sum_j w_j v_{ij} \]

Table 10. Second-level feature weight ranking

|    | B1    | B2    | B3    | B4    |
|----|-------|-------|-------|-------|
|    | 0.389 | 0.153 | 0.389 | 0.069 |

Table 11. Three-level feature weight ranking

| Third level indicators | Third-level indicator weight | Second-level indicator weight | Total weight |
|------------------------|------------------------------|-------------------------------|-------------|
| C1                     | 0.25                         | 0.389                         | 0.097       |
| C2                     | 0.75                         |                               | 0.292       |
| C3                     | 0.6                          |                               | 0.092       |
| C4                     | 0.2                          | 0.153                         | 0.031       |
| C5                     | 0.2                          |                               | 0.031       |
| C6                     | 0.087                        |                               | 0.034       |
| C7                     | 0.274                        | 0.389                         | 0.107       |
| C8                     | 0.639                        |                               | 0.249       |
| C9                     | 0.639                        | 0.069                         | 0.044       |
| C10                    | 0.274                        |                               | 0.019       |
| C11                    | 0.087                        |                               | 0.006       |

From the above analysis, it can be concluded that among the four main constraints of the prefabricated building, the order of importance is the policy factor, the economic factor, the technical factor and the industrial factor. Therefore, the prefabricated building does need policy support at an early stage of development and can not be much less expensive than a cast in place concrete building.

Among the second-level factors, the factors with a weight greater than 0.09 are C2, C9, C8, C1, C4, and the specific constraints are as follows:

Among the policy factors, the more restrictive factors affecting prefabricated buildings are the
insufficient incentives for prefabricated buildings and the lack of practical technical standards. The most influential constraint among technical factors is the imperfect modulus system. Among the economic factors, the most influential constraints are the lack of scale effect and the insignificant short-term economic benefits. The most influential constraint among industrial factors is the lack of a complete industrial chain. Through Analytic Hierarchy Process (AHP), the weight of each factor is analyzed, and finally the size of each factor is obtained and sorted. Through the analysis of the factors restricting the development of prefabricated buildings, the reasons behind them are analyzed, laying a foundation for giving solutions.

4. Suggestions for the development of prefabricated buildings in Chongqing

4.1 Technology Promotion Strategy
Prefabricated building measures are based on technical standards, production applications, and the development of BIM technology, as shown in figure 1.

![Promoting measures for prefabricated building technology](image)

Figure 1. Promoting measures for prefabricated building technology

4.2 Economic promotion strategy
The cost reduction measures for prefabricated buildings are shown in Figure 2.

![System diagram of prefabricated building cost reduction](image)

Figure 2. System diagram of prefabricated building cost reduction
5. Summary
The development foundation of prefabricated buildings is different in each city. According to different regions, different development paths of prefabricated buildings are adopted to actively and effectively promote the development of prefabricated buildings in Chongqing according to local conditions. Based on a systematic analysis of the constraints on the development of prefabricated buildings in Chongqing, this paper puts forward some countermeasures and suggestions in line with Chongqing's market conditions, and provides useful reference for the development of prefabricated buildings in Chongqing, thus promoting the popularization and development of prefabricated buildings in Chongqing and promoting the industrialization process of Chongqing's construction industry.

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