ANALYSIS AND RESEARCH ON THE FACTORS INFLUENCING THE DESIGN OF ASSEMBLED BUILDINGS

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Abstract: Based on the previous research on the current situation of the application of assembly design, this paper identifies 14 influencing factors that cause the problems of assembly design by combining the literature research method and the Delphi method. In order to ensure the accuracy and appropriateness of the influencing factors, a questionnaire survey was conducted among the professionals and technicians who had worked on assembly building design projects, and 10 major influencing factors were selected by the magnitude of the influencing factors. Then, using expert interviews, the 10 factors were ranked in terms of their application to the assembly building design process, and finally five important factors influencing the assembly building design process were derived. The theoretical basis for future research on the optimization of assembly building design was laid.

1. Introduction

The results of assembled building design are the embodiment of team organization structure, design personnel, design process division, and comprehensive use of technical methods, and have many unique characteristics. As the architectural design units carry out assembled building design, a series of problems arise in terms of cost, quality, and cycle time, and affect the effect of assembled building application. The assembled building design is a complex and systematic design activity that is influenced by a series of factors. Therefore, this paper will identify the key influencing factors that affect the design of assembled building, and provide a basis and foundation for optimizing and improving the design of assembled building using the influencing factors in the future.

2. Ideas and principles of impact factor identification

2.1. Ideas for impact factor identification

In this paper, firstly, through the literature review method, the Subscribe to DeepL Pro to edit this document, influencing factors of domestic and foreign experts and scholars in assembly building design were initially studied and organized, secondly, the current situation and problems in the development of assembly building design application were organized and the influencing factors of
assembly building design were analyzed, again, the influencing factors analyzed were further revised and supplemented through the expert interview method, and finally, using the questionnaire survey method, the analyzed influencing factors will be selected according to their importance.

2.2. Principles of influence factor identification

1) Scientific principle
The content of the influence factor definition must be clear and must be scientific, an objective factor that can withstand repeated reasoning. The identification of impact factors of assembled building design is to improve design quality and efficiency and reduce design costs, so the identification of impact factors of assembled building design must be scientific in order to correctly guide and help design enterprises to optimize assembled building design.

2) Principle of representativeness
The identified influencing factors should have a high degree of importance and recognition. Therefore, in this paper, the influence factors are identified by questionnaire method for scoring the degree of influence, and the factors with low degree of influence are excluded, so that the identified influence factors can accurately corroborate the current problems.

3) Principle of comprehensiveness
There are many influencing factors affecting the design of assembled buildings. There are many factors, and in order to make the influencing factors identified in this paper more comprehensive, this paper identifies the influencing factors through literature research and adds important obstacle factors by combining the current design situation and expert interviews to avoid omissions and thus ensure the comprehensiveness of the influencing factors.

3. Preliminary identification of influencing factors

3.1. Identification of influencing factors based on relevant literature
The development of assembly building in China is still in its initial stage, and the research literature on the influencing factors of assembly building design is small, while the influencing factors in assembly building production and construction have similar commonality with it. Therefore, in this paper, the identification of the influencing factors of the assembled building design is extended to the assembled building production and construction, and the influencing factors are extracted from them by combining the characteristics of the assembled building design. Through intensive reading and repeated refinement of the literature, a total of 18 "influencing factors of assembly design" were identified, covering various aspects such as process management, technology, personnel, and organization management, as shown in Table 1.

| Serial number | Factors affecting the effectiveness of assembly design |
|---------------|------------------------------------------------------|
| F1            | Project participants, insufficient team communication and coordination |
| F2            | Low level of sharing of information among project participants |
| F3            | Poor information feedback and coordination between design and production and construction |
| F4            | Low participation of construction and production units in design |
| F5            | Poor planning, control and problem solving skills of project design managers |
| F6            | Insufficient managerial awareness of project design planning and control |
| F7            | Insufficient experience of the design unit or design team to carry out project design |
Factors affecting the effectiveness of assembly design

| Serial number | Factors affecting the effectiveness of assembly design |
|---------------|-------------------------------------------------------|
| F8            | Low level of ICT technology (e.g. BIM technology) application in the project design process |
| F9            | Inadequate assembled design standards and specifications |
| F10           | Strict government requirements for sustainable construction projects |
| F11           | Complexity of assembled design projects |
| F12           | More stringent quality requirements for projects |
| F13           | Design team organization structure is not reasonable |
| F14           | Lack of policy incentives and support related to assembled buildings |
| F15           | Difficult design of component nodes |
| F16           | Imperfect industrial chain |
| F17           | Designers with a large pool of expertise |
| F18           | Unreasonable design phase division setting |

3.2. Identification of influencing factors based on current problems

After combining and supplementing the 18 influencing factors extracted from literature combing with the current situation of assembly building design and the problems of factors existing in the current situation, the following list of 20 influencing factors was finally obtained, as shown in Table 2.

Table 2 preliminary summary of influencing factors

| Serial number | Factors affecting the effectiveness of assembly design |
|---------------|-------------------------------------------------------|
| F1            | Project participants, insufficient team communication and coordination |
| F2            | Low level of sharing of information among project participants |
| F3            | Poor information feedback and coordination between design and production and construction |
| F4            | Low participation of construction and production units in design |
| F5            | Poor planning, control and problem solving skills of project design managers |
| F6            | Insufficient managerial awareness of project design planning and control |
| F7            | Insufficient experience of the design unit or design team to carry out project design |
| F8            | Low level of ICT technology (e.g. BIM technology) application in the project design process |
| F9            | Inadequate assembled design standards and specifications |
| F10           | Strict government requirements for sustainable construction projects |
Factors affecting the effectiveness of assembly design

| Serial number | Factors affecting the effectiveness of assembly design |
|---------------|------------------------------------------------------|
| F11           | Complexity of assembled design projects             |
| F12           | The owner has strict quality requirements for the project |
| F13           | Design team organization structure is not reasonable |
| F14           | Lack of policy incentives and support related to assembled buildings |
| F15           | Difficult design of component nodes                  |
| F16           | Imperfect industrial chain                           |
| F17           | Designers with a large pool of expertise             |
| F18           | Unreasonable design phase division setting          |
| F19           | High cost of assembled buildings                     |
| F20           | Low standardization rate of components                |

3.3. Correction of influence factors based on Delphi method

The influence factors identified through the literature research method and based on the current problems of assembly building design have the following problems: 1) there are limitations and timeliness in the literature collection; 2) the definition of their influence factors lacks accuracy, which has an impact on the next questionnaire survey; 3) whether the above factors are appropriate as influence factors. In order to ensure that the extracted assurance influence factors are comprehensive and current, they need to be further screened and amended, and this paper chooses the Delphi method to further amend the influence factors of assembly building design.

Experts were first asked to express their opinions on whether to add, remove, and modify the barrier factors, and then invited to evaluate the suitability of the modification of the influencing factors until the final survey results converged. The experts' opinions on the modifications based on the survey results are summarized in Table 3.

| Modification Comments                                                                 | Reason                                                                 |
|---------------------------------------------------------------------------------------|------------------------------------------------------------------------|
| Removal of strict government requirements for sustainability of construction projects. | It is a necessary requirement for architectural design, not an influencing factor. |
| Remove the complexity of assembly design projects.                                     | Performance of design refinement requirements for assembled design projects, not influencing factors. |
| Remove the owner's strict quality requirements for the project.                        | High quality requirements are an implementation standard for assembly building design, not an influencing factor. |
| Remove the lack of policy incentives and support related to assembled buildings        | Related to design motivation of assembled buildings, not related to design influences. |
| Remove the high cost of assembled buildings.                                           | Related to the resistance to the implementation of assembled buildings, not to the influencing |
4. Screening of influencing factors

4.1. Questionnaire
The 20 identified influencing factors for the application of assembly building design were corrected by Delphi method, and finally 14 influencing factors were obtained. This study again investigated the degree of influence of the influencing factors by using questionnaires, so as to filter out the main influencing factors.

4.2. Reliability test
Reliability refers to the stability and reliability of the results measured using a measurement instrument, and reliability analysis can be used to measure the extent to which measurement results are reliable and stable. This paper focuses on testing the consistency reliability of the survey questionnaire, and reflects the internal consistency of the scale by measuring the Cronbach coefficient, which is usually considered to be quite high when the Cronbach coefficient is $>0.7$ [12]. SPSS 19.0 was applied to analyse and calculate the data, and the results are shown in Table 4.

| Cronbach's Alpha | Number of items |
|------------------|-----------------|
| 0.812            | 14              |

From the data in the table, the reliability analysis of the original questionnaire data shows that the Cronbach's Alpha coefficient for the 14 items is 0.812, which is greater than 0.7, indicating that each item has good internal consistency.

4.3. Screening of important obstacle factors
The mean values of each of the 14 barriers were calculated for the influencing factors with high reliability after the questionnaire analysis. The size of the mean value reflects the degree of influence of the influencing factors, and the larger the mean value, the higher the degree of agreement. Therefore, the influence factors were ranked according to their mean values, and the mean values of each influence factor are shown in Table 5 below.

| Influencing Factors                                      | Average value | Sort by |
|---------------------------------------------------------|---------------|---------|
| Project participants, insufficient team communication and coordination | 4.41          | 1       |
| Low level of sharing of information among project participants | 4.38          | 2       |
| Design team organization structure is not reasonable    | 4.25          | 3       |
| Unreasonable design phase division setting              | 4.12          | 4       |
| Low level of ICT technology (e.g. BIM technology) application in the project design process | 4.01          | 5       |
| Designers with a large pool of expertise                 | 3.79          | 6       |
| Inadequate assembled design standards and specifications | 3.63          | 7       |
Influencing Factors Average value Sort by
Low standardization rate of components 3.53 8
Insufficient experience of the design unit or design team to carry out project design 3.47 9
Low participation of construction and production units in design 3.38 10
Poor planning, control and problem solving skills of project design managers 2.89 11
Insufficient managerial awareness of project design planning and control 2.83 12
Difficult design of component nodes 2.79 13
Imperfect industrial chain 2.76 14

The above statistics show that the mean values of key influencing factors range from 2.76 to 4.41. Yuan [13] analyzed that factors with mean values greater than 3 could be considered as important factors, while LuShen [15] suggested that factors with mean values greater than 4 should be considered as important factors. In order to ensure the rigor and comprehensiveness of factor screening, factors with mean values above 3 were considered as important factors, and factors with mean values less than 3 were further analyzed and judged by the key factor area value method, i.e., when the cumulative and proportional share of high-intensity impact areas (i.e., areas with intensity values of 3, 4, and 5) was greater than 80%, the factor was judged to be important [11]. Table 6 was obtained by analyzing the data.

| Influencing Factors | Huge impact (5) | Significant impact (4) | Partial Impact (3) | The impact was not significant (2) | No effect at all (1) |
|---------------------|-----------------|------------------------|-------------------|---------------------------------|-------------------|
| Poor planning, control and problem solving skills of project design managers | 10 | 14 | 38 | 45 | 14 |
| Insufficient managerial awareness of project design planning and control | 9 | 15 | 40 | 47 | 10 |
| Difficult design of component nodes | 11 | 16 | 42 | 45 | 7 |
| Imperfect industrial chain | 12 | 13 | 45 | 38 | 13 |

The weight of the high-intensity impact area of each factor in the above table is calculated, and all of them are less than 80%, so they should not be considered as important factors.

Comprehensive analysis of the above data finally yielded 10 important influencing factors. In Table 5 on the extraction of the influencing factors of the assembly building design, the influencing factors with a mean value greater than 3 were taken as the important influencing factors, which has ensured the rigor and comprehensiveness of the factor screening. Therefore, the factors with a mean value greater than 4 in the ranking of the influencing factors of the assembly building design process were further considered as important factors. Summing up the above data, we finally concluded that the five factors affecting the process of assembled building design are: insufficient communication and coordination among the project participants' teams; low sharing of information among the project participants; unreasonable organizational structure of the design team; unreasonable setting of the design phase division; and low application level of ICT technology (such as BIM technology) in the project design process.
5. Summary
Through the study, five important factors affecting the process of assembly building design were finally concluded: insufficient communication and coordination among project participants, team; low level of information sharing among project participants; unreasonable organizational structure of design team; unreasonable setting of design phase division; and low level of application of ICT technology (such as BIM technology) in the project design process. The study of these influencing factors will be an important data support and theoretical basis for the subsequent study of assembly design.

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