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Research on the Development Status and Influencing Factors of Prefabricated Buildings in China

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Abstract

Housing is essential for people's livelihoods, and architecture is the fundamental guarantee for human life and production. Since the reform and opening up, the Chinese construction market has developed rapidly. In recent years, with the progress of social, cultural, and technological factors, prefabricated buildings have been vigorously promoted in China. This article analyzes the current de-velopment status and influencing factors of prefabricated buildings in China through literature analysis, expert interviews, and field research. Based on the results, corresponding improvement measures are proposed to promote the high-quality development of prefabricated buildings in China.

Keywords

Prefabricated; Development; Influencing factors; Quality.

1. Introduction

Since ancient times, the most fundamental needs of human life have been clothing, food, shelter, and transportation, and infrastructure construction, in addition to the natural environment, is a direct or indirect condition for meeting these basic needs. Since the founding of the People's Republic of China, the national economy, technology, and culture have all undergone qualitative improvements, especially the rapid development of the infrastructure industry, which has been dubbed the "infrastructure maniac" by many countries. According to previous reports, China's building area exceeded 70 billion square meters in 2021, with a total carbon emis-sions of 5.01 billion tons of CO2 from the entire building process. The total energy related carbon emissions in the country are 10.64 billion tons of CO2, with the construction industry accounting for about 50%[1]. The traditional construction situation is characterized by severe pollution, labor consumption, and long construction cycles, which no longer conform to the current trend of intelligent, industrialized, and green de-velopment in society. Therefore, driven by various factors, China's construction industry is actively transforming from traditional concrete buildings to prefabri-cated buildings. Prefabricated buildings have the advantages of fast construction speed, low pollution, reliable quality, and labor-saving. However, due to their short promotion time in China, incomplete relevant standards and specifications, and immature technology, there are some obstacles to their development. There-fore, this article analyzes this issue, explores the influencing factors of prefabri-cated building development, and proposes corresponding suggestions based on the research results, in order to promote the high-quality and rapid development of prefabricated buildings in China.

2. Basic Concepts and Development Status of Prefabricated Buildings

2.1. Basic concepts of prefabricated buildings

The abstract understanding of prefabricated buildings is to connect houses like building blocks, transfer multiple on-site construction procedures of traditional concrete buildings to factories

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for the production of prefabricated components, and then transport them to the site. Through lifting and other techniques, the components are assembled to form the target building, which has the advantages of green environmental protection, fast construction speed, and labor saving. The construction process can be simply divided into design, prefabricated component production, transportation, and construction acceptance.

2.2. Development history and current situation of prefabricated buildings

The earliest application of prefabricated buildings in China was in the 1950s, mainly to meet the reconstruction needs after the Tangshan earthquake. In recent years, due to the severe damage to the global ecological environment caused by the rapid development of human society, China and many countries around the world have actively promoted green development; In the context of the continuous development of the country, we support the transformation of various industries from traditional manual operations to modern industrialized production methods. Taking into account multiple social development needs, since 2013, the country has vigorously promoted the development of prefabricated buildings. Local governments have also followed the guidance of the central government and formulated multiple practical implementation strategies. As a result, prefabricated buildings have sparked a craze in the Chinese construction industry.

As early as December 2015, the country proposed that the proportion of prefabri-cated building area to newly built building area should reach over 30% by 2025. According to the official website of the National Bureau of Data and Statistics, the period from 2016 to 2020 was a period of rapid growth, reaching 20.5% in 2020; The period from 2020 to 2023 belongs to a steady improvement stage, reaching 28.5% in 2023; In 2024, the proportion of some regions will significantly increase, such as Huaifang City reaching 40%; Based on the development situation in the past two years, achieving the goal of 30% by 2025 is just around the corner. Ac-cording to a research institution's prediction, the average annual growth rate (GARG) of China's prefabricated modular integrated building market will reach 15% from 2023 to 2028, and by 2028, the market size of prefabricated modular inte-grated buildings will reach 310 billion yuan[2]. In China, prefabricated building technology has mainly been applied to affordable housing and govern-ment investment projects. With continuous practice, prefabricated technology and the market have significantly improved. Currently, its application scope is expanding from residential buildings, public buildings to infrastructure and rural buildings. However, considering the slowing growth trend of prefabricated build-ings, there are still many problems in their practical application. The development of prefabricated buildings in China still has a long way to go. The following article will analyze the factors affecting the development of prefabricated buildings.

3. Support for the Development of Prefabricated Buildings

3.1. Policy support

Since 2016, multiple policies and guidance have been introduced at the national level to promote the development of prefabricated buildings. Local governments have also actively responded to the central call and issued implementation opinions in their respective regions, clarifying corresponding work goals, implementation scope and standards, as well as key work tasks. If the government provides policy support such as area rewards, financial rewards, tax and fee policies, and image progress for developers, and in the recommended directory of energy-saving and carbon reduction technology and equipment released by the Ministry of Industry and Information Technology of the People's Republic of China in 2024, it is mentioned that green construction will become an important indicator for applying for provincial high-quality projects, Luban Awards, etc. Prefabricated buildings, as an important part of green

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construction, will become the main construction form of the future construction industry under the support of multiple policies

3.2. Social support

The country is progressing and society is developing. Nowadays, all industries are moving towards intelligence, industrialization, and other directions. Human pur-suit of quality of life is also increasing. Therefore, there will be a certain market demand for the renovation of old urban housing, affordable housing, rural housing, and other buildings in the future[3]. In addition, under the background of rapid development, the global ecology has been severely damaged. Therefore, countries have formulated response measures from multiple aspects and promoted the concept of energy conservation, environmental protection, green and low-carbon. As a pillar industry of China's national economy, the construction industry must implement this concept; With the arrival of an aging population, the issue of labor shortage must be considered. Compared to traditional buildings, prefabricated buildings can significantly reduce labor and adapt to this change. At the same time, it can also promote structural adjustment and technological up-grading within the construction industry, driving the industry towards higher lev-els and more sustainable development[4]. Therefore, considering various factors, the development of prefabricated buildings is an inevitable result of the transformation of the construction industry under social development.

4. Constraints on the Development of Prefabricated Buildings

4.1. Cost constraints

Prefabricated buildings still face the challenge of high costs. Studies have shown that the cost of civil engineering projects using prefabricated concrete structures is 10% to 20% higher than cast-in-place structures, which to some extent hinders the promotion and development of prefabricated buildings[5]. The main reasons for the high cost of prefabricated buildings are as follows: firstly, the pro-duction of prefabricated components has high requirements for raw materials, and corresponding molds need to be developed according to project design, which re-quires funds for mold design, production, and maintenance; Secondly, due to the large volume and self weight of prefabricated components, there are high require-ments for equipment, routes, etc. during transportation, and component damage problems are prone to occur, resulting in increased costs; Thirdly, due to the lim-ited level of prefabricated technology and immature industrial chain, there are high management costs in the corresponding production and manufacturing pro-cesses.

4.2. Conceptual constraints

For a long time, the status of concrete building structures in the hearts of the peo-ple as a form of construction has been deeply rooted. Due to the limited under-standing of prefabricated buildings during their development period, many people are unable to theoretically recognize their building quality; Secondly, due to its relatively low market share and the fact that the quality of prefabricated buildings has not yet been tested by time, people cannot objectively recognize its quality level. Ideas and concepts dominate people's actions, and when the public does not recognize or hold doubts, their development is largely constrained.

4.3. Technical constraints

In the decade of rapid development of prefabricated buildings, there have been many breakthroughs and innovations in technology, but the overall level of tech-nology is still relatively low. For example, during the construction phase, there are technical difficulties in waterproofing board joints, leveling and grouting of floor slabs, and joint splicing, which result in the engineering quality level not reaching the ideal state. This is also an important reason

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why it is difficult to apply a 100% assembly rate in actual engineering[6]. In addition to construction technology, the application level of information technology is also relatively low. The application scope of information technology such as BIM and artificial intelli-gence in practical engineering is narrow. For example, it is not possible to achieve complete and real-time quality problem tracking and tracing in the entire process of building production and construction. The main reason for this problem is the small investment in technology research and development and the lack of practi-cal opportunities.

4.4. Market constraints

As a populous country, China has a high demand for construction. However, due to the rapid development of the domestic real estate market in recent years, the cur-rent residential buildings in China are in a saturated state. In recent years, there has been a downward trend in the real estate market in almost all provinces and cities. There is no longer the phenomenon of speculation in real estate, and peo-ple's desire to buy houses has significantly decreased. Except for essential housing, few people are reinvesting in real estate. Therefore, due to the saturation of exist-ing housing and the decrease in purchasing desire, new construction projects are limited, and this market environment also limits the development and application of prefabricated buildings.

4.5. Lack of professional talents and low professional level

The rapid development of prefabricated buildings in the market began in 2016, before which China's prefabricated building projects accounted for a very small proportion of newly started construction. Without project application, there are no personnel engaged in related technologies. Although a group of prefabricated technical talents have been trained in project practice in the past decade, they have also made progress through exploration and do not have a high level of spe-cialization; On the other hand, the relevant professionals trained on campus under the combination of industry, academia and research have not yet reached the pro-fessional level they should have in recent years. In addition, research has shown that from 2022 to 2025, there will be a gap in the demand for technical and skilled personnel in green building technology at all educational levels, with a significant gap in vocational and undergraduate programs[7]. With the aging population and the problem of young people's employment concepts, the demand for talent is not met.

4.6. Imperfect constraints on relevant standards, norms, and institutional systems

The country attaches great importance to the development of green buildings, and the development of green and industrialized buildings has become an important core of the construction industry. Since 2016, the country has introduced multiple policies to promote prefabricated buildings, and local governments have actively responded by formulating specific implementation plans. In 2014, the "Work Plan for Accelerating Energy Conservation and Carbon Reduction in Building Areas" proposed to deepen green construction, promote energy conservation and carbon reduction in building areas, and promote comprehensive green transfor-mation[8]. However, due to the short practical time, narrow application scope, multiple involved objects, different actual situations in various regions, and the large number of enterprises in the industry, a unified and standardized stand-ard and institutional system have not yet been fully formed. Only four provinces and cities across the country, namely Tianjin, Guangdong, Sichuan, and Chongqing, have issued clear quality management policy standards[9], while the lack of industry norms and technical standards in China has led to low levels of building standardization and difficulty in controlling quality management.

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5. Development Strategies for Prefabricated Buildings

Based on the previous analysis of the constraints on the development of prefabri-cated buildings, this study proposes the following development strategies.

5.1. Guided by policies, expand the prefabricated construction market

The national and local governments constantly pay attention to the situation of the pre fabricated construction industry, identify key development issues, and ac-tively introduce response measures. Various forms of encouragement and support are provided to enterprises for the development of prefabricated construction, promoting the market share of prefabricated construction from the perspective of enterprises. At the same time, we should consider how to popularize prefabricated green buildings, which are in line with the development direction of the times, more intuitively to the people, integrate the practical advantages and achieve-ments of prefabricated buildings, and enhance public recognition.

5.2. Increase research and development investment to break down tech nological barriers

Technological advancement is a key node in development, and both the govern-ment and enterprises should increase investment in prefabricated building tech-nology in different ways and methods. For construction and production tech-niques, under the conditions of controllable quality and cost, we should be brave enough to try new things and make mistakes, develop new materials and explore new methods to change the current technical difficulties; We should encourage and reward researchers to develop new platforms for information technology, and combine existing intelligent technologies to empower the construction and pro-duction of prefabricated buildings.

5.3. Pay attention to talent cultivation and improve the professional qual ity of practitioners

At present, the automation level of prefabricated buildings is still very low, and many tasks require people to complete. Therefore, the professional level of people determines the quality of this work. On the one hand, it is necessary to increase training and learning for personnel, and enhance their professional abilities through typical case talent exchange, professional theoretical learning, and opera-tional method training; On the other hand, we will strengthen the cooperation between industry, academia, and research, and strive to implement the results, maximizing the combination of scientific research and practice.

5.4. Establish and improve the industry standard system and norms

In response to the current problem of incomplete system standards in the prefab-ricated construction industry, relevant units should actively integrate and sum-marize various standard specifications based on existing experience in each link. At the same time, key research and discussion should be organized for vague and unclear objects, and appropriate data should be corrected by combining multiple cases. System specifications in different regions and under different conditions should be classified and processed according to actual situations.

6. Conclusion

The development of prefabricated buildings in China is on the rise, and under pol-icy guidance and social development drivers, prefabricated buildings will inevita-bly become the mainstream architectural trend in the future. This article analyzes the current development status and influencing factors of prefabricated buildings in China, and proposes policy guidance to expand the prefabricated building mar-ket based on the analysis results; Increase R&D

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investment and break down tech-nological barriers; Pay attention to talent cultivation and improve the profession-al quality of practitioners; Establishing a sound industry standard system and standardizing four development suggestions, hoping to promote the high-quality and rapid development of prefabricated buildings in China.

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