The promotion of digitalization of traditional construction industry by new technology: Take construction robots and prefabricated construction for example

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Abstract: *This paper mainly discusses the application of construction robots in the field of construction with the background of carbon peaking and carbon neutrality,focusing on the feasibility study and development prospect study.Taking dual carbon as the background,case study method and feasibility study method are adopted to put forward the scientific development path.This paper can provide reference for the application of "Robot+Prefabricated building"in the construction field and the development path research of the construction industry under the background of carbon peaking and carbon neutrality.*

Keywords: *Double Carbon, Construction robot, Prefabricated building, Prefabricated building*

1. Introduction

1.1 Research content

At present, the research on the digital transformation of the construction industry mainly focuses on the application of digital technologies such as BIM. Domestic and foreign scholars have conducted more studies on the construction of digital technology application index system, but less studies on its mutual influence and promotion path[1].

Some scholars have discussed the application of a single robot in the field of construction, but the development of robots is changing with each passing day, and there are many new tools that need to be integrated. In order to provide scholars and practitioners with more reference theoretical research, this paper will study the digital promotion of construction robots and assembly construction on China's traditional construction industry from a macro perspective.

This paper focuses on the analysis of the literature research process and development process related to robot + fabricated in the field of architecture, and the feasibility analysis of the improvement of the digital level in the traditional construction industry under the continuous penetration of construction robots and assembly construction.

1.2 Research methods and data sources

Based on the citespace visual analysis software, this paper analyzes the literature data obtained from the knowledge network, aiming to show the penetration of construction robots and assembly-type into the traditional construction industry from the changes in the number of literatures and the main contents of literatures. The research method is mainly literature analysis, a large number of secondary data, combined with previous studies, sorting and summarizing, and effectively grasp the overall context of the application of construction robots in the construction field. The data mainly comes from the knowledge network and the data published by the National Bureau of Statistics and the financial statements of enterprises.

2. Digitization of construction industry

2.1 Current situation of digitization in construction industry

The slow digitization process of China's traditional construction industry is not only reflected in the lack of Information-based talents, data island hinder the flow of data, but also reflected in the lack of correct cognition of digitalization in the entire industry.

At present, the digitalization of the construction industry lacks diversity and specialization, the understanding and application of technology is not enough, and the policy support is increased, but it also faces problems that are not conducive to the promotion and implementation of responsibilities, the implementation of responsibilities is not in place, the evaluation standards are not uniform, and the application and promotion of new technologies are slow.

2.1.1 The two-carbon target has made new technologies urgently needed in the construction industry

The term "Double Carbon" refers to the combination of carbon peak and carbon neutral. In 2020, China explicitly proposed the double carbon goal. In 2021, the CPC Central Committee and The State Council issued the "Opinions on Achieving Complete, Accurate, and Comprehensive Implementation of the New Development Concept for Carbon Peak and Carbon Neutral". Various sectors have taken measures to achieve this goal. Practice shows that the application of innovative technology is the key to achieve carbon emission reduction. The application of robots in the construction field will also bring a turning point to the high carbon status quo of the construction industry.

According to a report released by the State Statistical Bureau in February 2022, the added value of the construction industry accounted for 7% of GDP in 2021, making a significant contribution to the domestic economy, but at the same time it is also facing the problem of excessive carbon emissions. The carbon emission of the construction industry accounts for nearly half of the national carbon emission, and plays an important role in realizing the target of greenhouse gas emission reduction.The Emission reduction process in the construction industry has a significant influence on China's realization of double carbon goal[2].

2.1.2 The construction industry is less digitized

The digital age, in which signals are transmitted in the form of computer languages such as "1" and "0", is an era of change in the way information exists, with digital technology as the rule of operation.The integrated development of the substantial economy and the digital economy has begun, and the scale benefits of the real economy driven by the digital economy have been gradually reflected, and digital transformation is no longer a "choice question", but an inevitable choice for high-quality and sustainable development[3].Therefore, it is necessary to solve the Realistic problems between carbon emissions and the environment while maintaining the high-quality development of the construction industry.

All walks of life have been affected by digitalization to carry out industrial transformation or are in the process of industrial transformation, the construction industry due to many branches, business types, low profits, weak consciousness and other factors, the overall digitalization of the industry is not high. The outbreak of the epidemic has fully exposed the defects of the digital transformation process in all walks of life, but the emergence of new technologies such as BIM, the Web of Things, and AI has also provided new digital development ideas for the construction industry.

3. Construction robots are helping to digitize the construction industry

3.1 Construction robot

As shown in Figure 1 robots can be divided into three categories: industrial robots, service robots and special robots. In 2020, the market size and development trend analysis report of China's robot industry analyzed the global market size of robots and the Chinese market size. Among them, Chinese industrial robots accounted for 48.29% of the global market size, which is the most popular robot type in China. Construction robots belong to industrial robots.

At present, China's construction industry volume is large, but the degree of information and intelligence is low, it is urgent to innovate and transform the industry, and the development of safe, efficient and intelligent construction robots is an urgent demand of the traditional construction

industry[4].Construction robots are machines that automatically or semi-automatically perform construction work, which can move by running preprogram or principles formulated by artificial intelligence technology, and replace or assist construction personnel in completing building construction processes such as welding, carrying, ceiling installation, paint spraying, etc.

At present, construction robots are also widely used in dealing with repetitive dirty, dangerous and heavy work, which can alleviate the pressure caused by labor shortage to a certain extent, save costs and shorten the construction period.
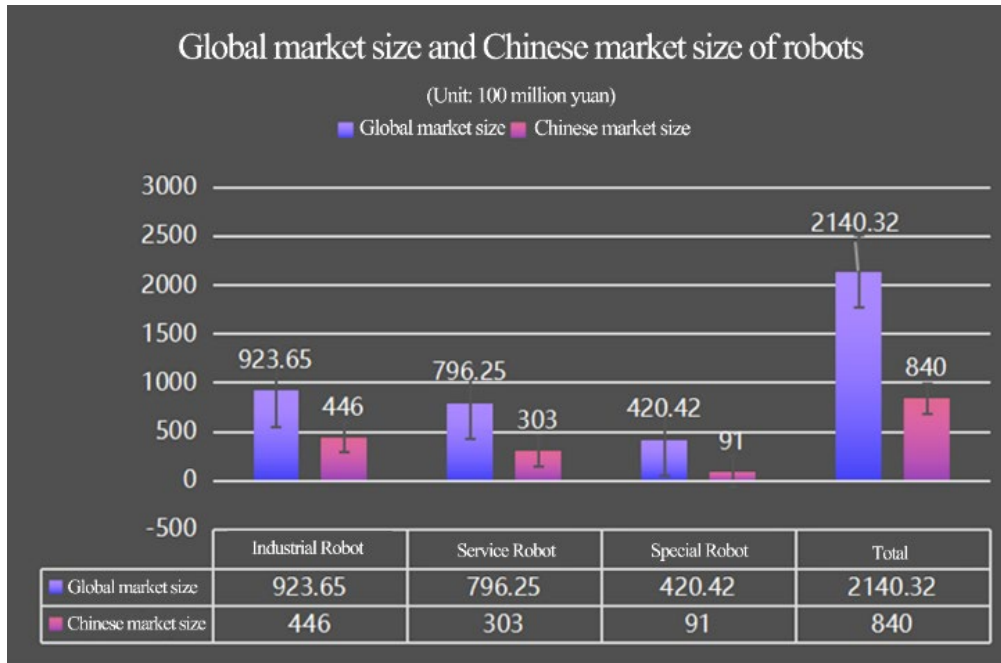

Figure 1: The global market size of robots and the market size of China in 2020 (Author's drawing)

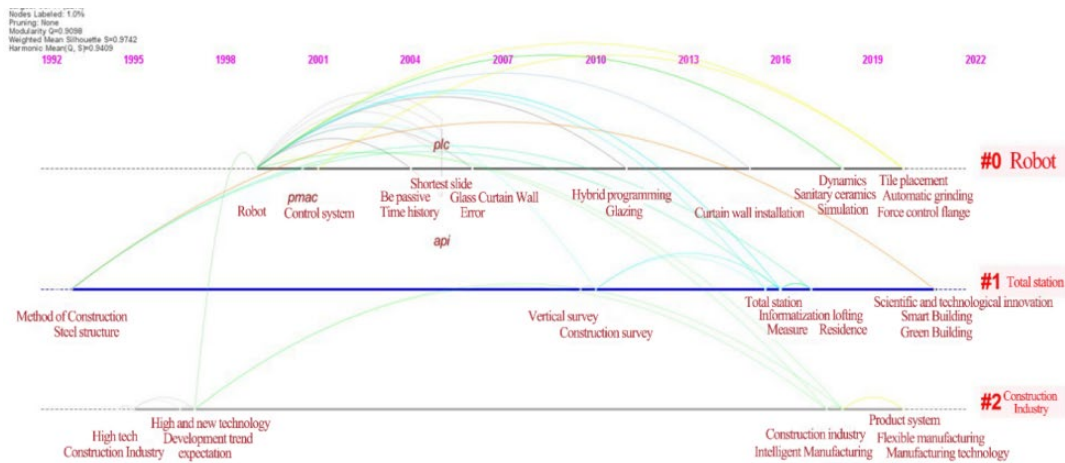### 3.2 The development process of construction robot related research

Figure 2: Citespace literature co-citation clustering time graph (architecture and robot as search terms, self-drawn by the author)

Figure 2 is a visual data analyzed by citespace, the relevant research process can be divided into the following stages.

The period from 1999 to 2016 was the introduction period of construction robots. Since 1999, Chinese scholars in the field of architecture have begun to conduct research on robots. Since then, the concept of robots has been widely used in the subdivision research fields of control system, curtain wall installation, dynamics and automatic grinding.

2016-2019 ushered in a small climax of robot development. During this period, the keyword of robot was widely cited in studies on total station and information lofting, which was closely related to the policies successively introduced in 16 years, and from then on, the frequency of one year policy was basically maintained and slowly advanced until 2019.

Promulgation time	Issuing department	Policy name	Main Content
2023.1	Ministry of Industry and Information Technology and other 17 departments	《Notice on the issuance of "Robot +" application action implementation plan》	By 2025, the density of manufacturing robots will double compared with 2020.Focus on 10 key application areas, break through more than 100 kinds of robot innovative application technologies and solutions, promote more than 200 robot typical application scenarios with high technical level, innovative application mode and significant application results, build a number of "robot +" application benchmarking enterprises.
2022.1	Ministry of Housing and Urban-Rural Development	《Vigorously promote the application of prefabricated buildings to accelerate the development and application of construction robots》	Form a number of construction robot landmark products. Actively promote the typical application of construction robots in production, construction, maintenance and other links, focusing on promoting the application of construction robots that are compatible with prefabricated buildings, and assisting and replacing "dangerous, complex, dirty and heavy" construction operations.
2021.12	Ministry of Industry and Information Technology and other 15 departments	《"14th Five-Year Plan" Robot Industry Development Plan》	By 2025, China will become a global source of robot technology innovation, a high-end manufacturing agglomeration and a new highland for integrated applications, with an average annual growth rate of more than 20% in the operating income of the robot industry and a doubling of the density of robots in the manufacturing industry.
2021.12	Ministry of Industry and Information Technology and other 8 departments	《"14th Five-Year Plan" Intelligent Manufacturing Development Plan》	70% of manufacturing enterprises above designated size have basically realized digital network--ing, and more than 500 intelligent manufacturing demonstration factories have been built to lead the development of the industry. The market satisfaction rate of intelligent manufacturing equipment and industrial software exceeds 70% and 50%, respectively, and more than 150 system solution suppliers with high professional level and strong service ability are cultivated.
2019.10	National Development and Reform Commission	《Guidance Catalogue for Industrial Restructuring (2019Annual)》	Industrial automation control systems and devices such as PLC, high-performance motors and drives, and fully autonomous programming are included in the encouraged category.
2017.12	Ministry of Industry and Information Technology	《Three-year Action Plan to Promote the Development of the New Generation of Artificial Intelligence Industry (2018-2020)》	By 2020, smart home service robots and smart public service robots will be mass-produced, and robots for medical rehabilitation, helping the elderly and disabled, fire fighting and disastereducation will be prototype produced.
2016.12	Ministry of Industry and Information Technology and Ministry of Finance	《Intelligent Manufacturing Development Plan (2016-2020)》	By 2025, the intelligent manufacturing support system will be basically established, and key industries will initially realize intelligent transformation.
2016.7	The State Council	《The 13th Five-Year Plan for National Science and Technology Innovation》	Research on cutting-edge technologies such as next-generation robotics, robot learning and cognition, human-computer natural interaction and collaborative integration will be carried out.
2016.3	Ministry of Industry and Information Technology, Development and Reform Commission, Ministry of Finance	《Robot Industry Development Plan (2016-2020)》	By 2020, we will cultivate more than 3 internationally competitive leading enterprises and build more than 5 robot supporting industrial clusters.

Figure 3:There are documents on construction robots for 2016-2023

2020 - Construction robots have entered a period of rapid development since now. Figure 3 summarizes the relevant policy documents from 2016 to 2023.The "Fourteenth Five-Year Plan" has repeatedly involved the development of strategic policies of construction robots, and robots have been widely cited in emerging topics such as scientific and technological innovation, smart construction, and green building since 2020, fully proving that the application of construction robots has promoted the intelligence of the construction field and accelerated the digitization process of the construction industry.

3.3 The development process of prefabricated construction related research

Prefabricated construction does not mean the same building appearance, but the prefabricated production of widely used buildings. The collocation of building colors and materials is not limited, effectively avoiding homogenization. Some buildings focusing on the use of functions can shorten the construction period and reduce the generation of construction waste through prefabricated construction. To a large extent, it solves the problem of excessive carbon emissions in the production stage of building materials, and brings the possibility of large-scale carbon reduction in the construction industry.

The data in Figure 4 from CNKI. Using "architecture" and "assembly" as keywords, 1463 literatures were searched, and visual data analysis was carried out with cite space. Most of the literatures on the theme of prefabricated type focus on the research of seismic performance of buildings, and there are also some researches on prefabricated,BIM, steel structures , etc. Through the literature co-cited clustering time graph, we can grasp the context of prefabricated construction research more directly.

Figure 5 clearly shows the cited keywords in the development process of prefabricated buildings, and the development process of this kind of research can be seen from these data.

The period from 1997 to 2007 was the initial period of exploration, during which prefabricated components began to be frequently used in research, and then related research declined precipice. Since 2008, the research on seismic performance and multi-storey apartment has continued to this day, which is related to the occurrence of Wenchuan earthquake in 2008. China began to pay attention to the aseismatic design in the building construction process, and prefabricated components are very

important for the installation of shock absorption and isolation devices. Subsequent studies mostly focus on the solution of seismic problems, and the research focuses on data and structural calculation.

2012 is a relatively important time node, BIM began to appear frequently, and the digitization process of the construction industry began to attract scholars' attention.
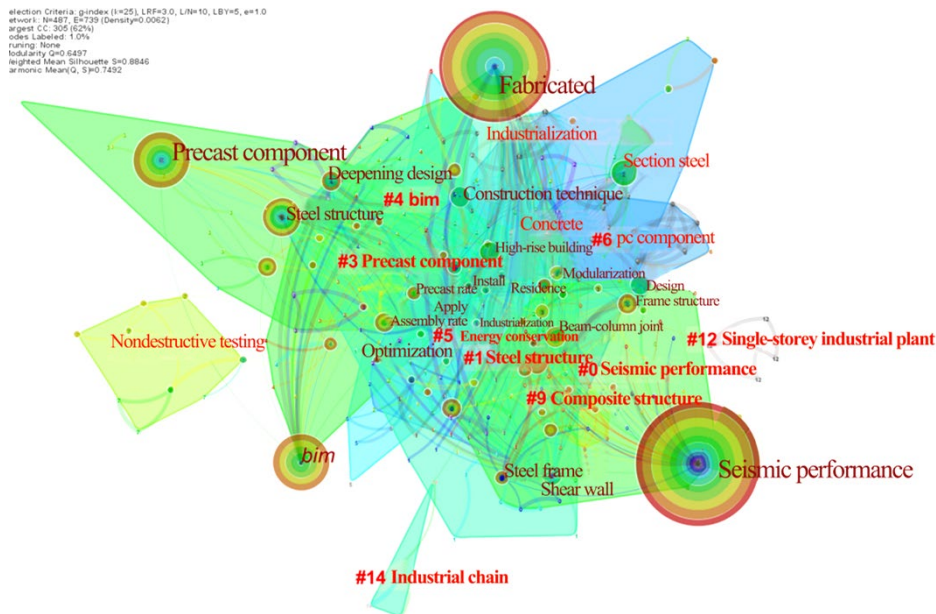

Figure 4: Citespace Keyword co-occurrence map (architecture and assembly as search terms, self-drawn by the author)
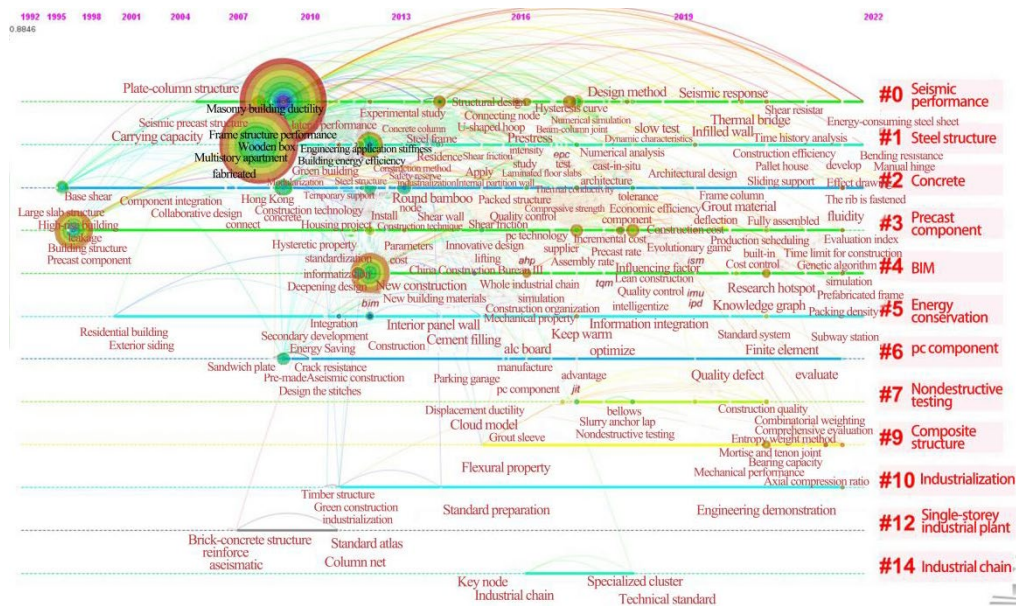

Figure 5: Citespace literature co-citation clustering time graph (architecture and assembly as search terms, self-drawn by t he author)

3.4 Feasibility analysis of construction robot + prefabricated construction

3.4.1 Policy support

In recent years, China has issued a large number of documents and trial operation measures, and paid full attention to construction robots and assembly construction. The "14th Five-Year Plan" robot Industry Development Plan proposes that by 2025, China will become the source of global robot technology innovation, high-end manufacturing gathering place and new highland for integrated application. We will raise the level of national scientific and technological innovation and high-end

manufacturing in research and development, manufacturing and application.

It is imperative to vigorously promote the development of prefabricated buildings, expedite research and development as well as application of construction robots, and establish a comprehensive policy framework and industrial system for the synchronized advancement of intelligent construction and new building industrialization. Endeavor to position "Chinese architecture" at the forefront of global core competitiveness while striving to attain world leadership in intelligent buildings.

3.4.2 The promotion of BIM application

As shown in Figure 5, beginning in 2012, scholars engaged in architectural research began to notice the importance of BIM. The core of BIM is to establish a virtual 3D model of construction engineering and use digital technology to provide a complete and consistent construction information base with the actual situation for this model.

In the future, the application of BIM will be more and more extensive, and the premise is that the Digitization level of the industry has reached a certain degree, so the traditional construction industry needs to rapidly improve digital technology to establish construction engineering information database. The application of BIM will also improve the utilization rate of information resources in the construction industry[5].The traditional construction industry needs to apply various new technologies to improve the level of digitalization in order to cope with the crisis of comprehensive digitalization and online in the era of the epidemic.

3.4.3 Urgent requirement of double carbon background

According to the 2022 China Building Energy Consumption and carbon emissions research report pointed out that in 2020, the total carbon emissions of the whole process of construction in China will be 5.08 billion tCO2, accounting for 50.6% of the national carbon emissions, of which the production stage of building materials accounted for 28.2% of the national carbon emissions, and the construction operation stage accounted for 21.6% of the national carbon emissions.

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4. Summarize

Assembly enables construction robots to be applied to more subdivided work, and the application of construction robots has brought great changes in the efficiency of assembly. The combination of the two has greatly promoted the process of digitization of the construction industry, and the frequent release of documents in recent years also proves that the government attaches great importance to the two. Therefore, construction robot + Prefabricated construction has the necessity of its promotion, and the combination of the two will bring many advantages:

(1)The assembly type expands the application range of construction robot;

(2)Construction robots support the production, transportation and installation of prefabricated buildings.

(3)The combination of the two has solved the problem of labor shortage in the construction industry to some extent.

(4)With the expansion of the application range of construction robots and assembly construction, a large number of labor forces have been liberated and can be used to support rural construction, which is conducive to the development of rural revitalization and the formation of a virtuous circle.

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