# Hotspot Analysis of Prefabricated Buildings from Different Perspectives by Literature Analyzing

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**Abstract.** Prefabricated building is a new type of building construction technology, but it is still a developing industry that needs constant exploration and improvement. Based on academic papers related to prefabricated buildings in CNKI and WOS literature databases, this paper uses CiteSpace software as an analysis tool to analyze the research hotspots of prefabricated buildings in recent years, and summarizes its future research direction. The results of this paper show that the amount of literature on prefabricated buildings is increasing year by year worldwide. At present, the main research countries of prefabricated buildings are China, Australia and the United States. In recent years, the structural design and standardization of prefabricated buildings will continue to be the focus of attention. With the solution of related problems, prefabricated construction will become an effective and low-cost construction method. The analysis in this paper provides new insights into the development trend and future prospects of this emerging industry. Despite the convenience and sustainability benefits of prefabricated building technology, it still needs to be further refined. These findings contribute to a better understanding of the dynamics shaping the prefabricated construction industry and provide guidance for future research and development efforts.

**Keywords:** Prefabricated building, hotspots, CNKI, WOS, CiteSpace.

## 1. Introduction

Prefabricated building is a newly developed building type, which is convenient to construct and sustainable to environment. It has a distinguished characteristic that a large amount of on-site assembly work is greatly reduced compared to the original cast-in-place operation. Additionally, the more standardized the components, the higher the production efficiency, and the corresponding component costs will decrease [1]. Prefabricated building also meets the requirements of green buildings [2]. Prefabricated building's upsurge has been arisen from 2010, and became a mainstream trend of building in recent years. At present, research on prefabricated buildings mainly focuses on the technical research of prefabricated main structures, but neglects the mutual matching between structural systems, building maintenance, and building equipment [3]. In addition, the currently designed components and component factories are not easy to process and install, resulting in complex production and on-site assembly processes, greatly reducing production efficiency and increasing costs [4].

Nevertheless, prefabricated building is still a developing technology which need multitudes of revises and explorations to involve. There are amounts of papers conducting research on prefabricated buildings. By analyzing these papers, the hotspots' forecast of prefabricated buildings is concluded.

The paper aims at analyzing various properties of the papers from China National Knowledge Infrastructure (CNKI) and Web of Science (WOS). The reason of choosing China is that Chinese published most papers on WOS, indicating they have conducted lots of research on prefabricated buildings. The paper analyzes the trend of research publications related to prefabricated buildings over a specific period (2014-2023) using two databases, CNKI and WOS. Also, utilizing CiteSpace, keyword analysis is conducted to identify the keywords within the field of prefabricated buildings. Finally, the prospect of prefabricated buildings is estimated, such as research focuses in the early future.

# 2. Research Method

## 2.1. Analyzing Tools from CNKI and WOS

China Academic Journals Full-text Database, also known as CNKI, serves as a vital academic information service platform based on China's comprehensive knowledge resources. It provides access to global information services for domestic publishers, research institutes, design firms, and R&D units. CNKI has become a nationally recognized platform known for its authority, comprehensiveness, and accuracy, offering document analysis tools alongside search capabilities [5].

WOS is the most authoritative international platform for scientific literature retrieval, encompassing the most influential core journals and offering functions for retrieval, analysis, citation, and application. Users can conduct single-database or cross-database searches of all subscribed databases on the platform and utilize analysis tools. It includes core collections like Science Citation Index Expanded, Social Sciences Citation Index, Arts & Humanities Citation Index, and others, providing access to influential journals and conference proceedings worldwide [6].

There are simple analyzing tools on CNKI and WOS. For instance, the website counts the number of published papers every year. Therefore, the researcher can infer the year of prefabricated building upsurge and the trend of the industry. Also, number of publications from various countries is also counted by the analyzing tool.

## 2.2. CiteSpace

CiteSpace is a versatile, real-time, and dynamic citation visualization analysis software developed within the context of scient metrics, data, and information visualization. It analyzes potential knowledge embedded in scientific literature, presenting the structure, patterns, and distribution of scientific knowledge through visualization. The resulting visual representations are often referred to as "scientific knowledge maps" [7].

Papers related to prefabricated buildings are downloaded, and unrelated papers such as education area of prefabricated building are excluded. After collecting the literature data, keywords are extracted from the articles. These keywords represent important concepts and topics within the field of study in a specific period [8].

# 3. Results and Discussion

## 3.1. Literature Temporal Analysis

From 2014 to 2023, excluding irrelated ones, totally 1183 publications in CNKI related to prefabricated buildings are counted. From Fig. 1, the popularity of prefabricated buildings began on 2015, which shows a rapid increase in 2015-2017 period. Then a peak shows up in 2017-2021 period. After year 2021, the upsurge of prefabricated buildings declined at a slow, steady rate. The trend of prefabricated buildings publications in recent years shows prefabricated building is a newly developed industry, and its upsurge has been past, which indicates it has entered a stage of stable development.

In WOS database, there are total 3288 publications related to prefabricated buildings. The numbers of publications in every year are shown in Fig. 2. From Fig. 2, the trend of prefabricated buildings is continuously increasing, but in 2023, the trend began to slow down, which is different from CNKI database. The increasing trend shows the research about prefabricated buildings keeps being popular since 2014, After the increasing of 10 years, the field of prefabricated buildings has been a hot topic nowadays.

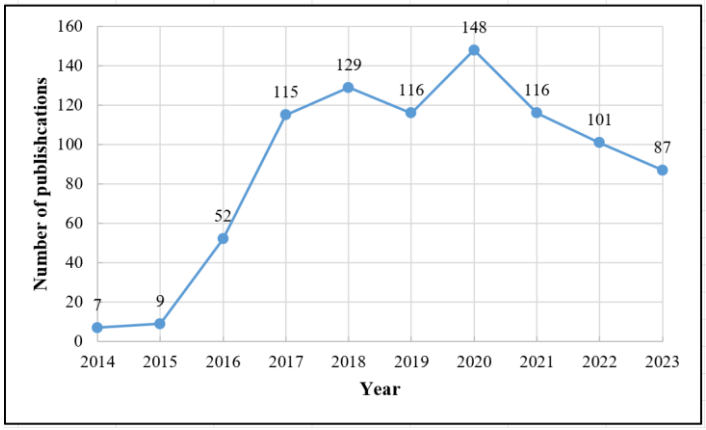


**Fig 1.** Number of Publications in CNKI from Year 2014 to 2023.

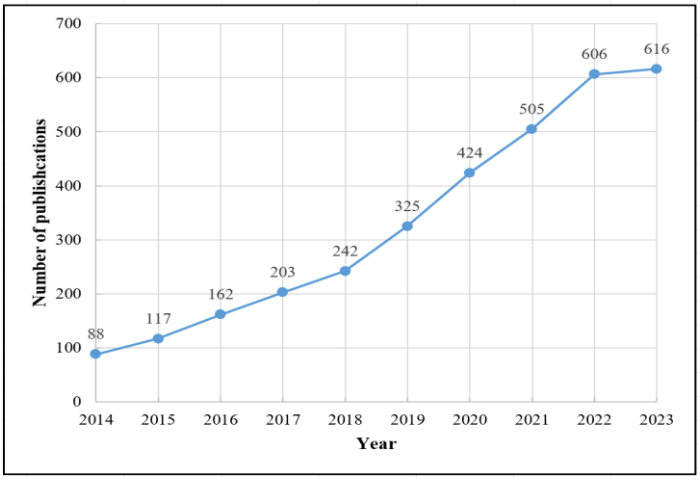


**Fig 2.** Number of Publications in WOS from Year 2014 to 2023.

### 3.2. Literature Quantities of Countries Analysis

Since CNKI contains only papers from China, papers from WOS are analyzed by analyzing tool on WOS website. It introduces the number of papers in one specific country published on WOS from 2014 to 2023 (Table 1). From Table 1, China's papers number of prefabricated buildings is far ahead with 7 times more than the second - Australia. The reason is China's rapid development of infrastructure in recent years encourages researchers to do research on prefabricated buildings. Besides, Australia also attaches immense importance to prefabricated buildings, since Australia keeps working on green energy policy in recent years. Its number of papers has been beyond USA's.

**Table 1.** Number of Publications from Various Countries.

| Publish Country | Number of Papers |
|---|---|
| People's Republic of China | 1656 |
| Australia | 277 |
| USA | 236 |
| Italy | 151 |
| England | 141 |
| Poland | 135 |
| Spain | 135 |

### 3.3. Literature Chronological Keywords Analysis

Utilizing CiteSpace, the key words in recent years are concluded (Table 2). Since key words are overmuch, only count those key words from 2016 instead of 2014. In Table 2, the second column is the upsurge year of the word, third column indicates how strong the word was at that time period

which between Begin and End. The frequency of the keywords is summarized in the last column as several bar charts respectively to every word. Table 2 reveals that Structure design, Standardization, Seismic performance are the most popular key words now, and expected to develop in the near future. Among them, Structure design has the highest strength, indicating it is the most popular topic nowadays.

**Table 2.** Keywords Analysis Based on CNKI from 2014 to 2023.

| Keywords | Year | Strength | Begin | End | 2014 - 2023 |
|---|---|---|---|---|---|
| Industrial chain | 2016 | 1.03 | 2016 | 2017 | |
| Green building | 2018 | 1.56 | 2018 | 2019 | |
| Industrial | 2018 | 1.19 | 2018 | 2020 | |
| High-rise building | 2018 | 1.19 | 2018 | 2019 | |
| Capacity | 2018 | 0.96 | 2018 | 2019 | |
| Structure | 2018 | 0.96 | 2018 | 2019 | |
| Assemble rate | 2019 | 1.97 | 2018 | 2020 | |
| Thermal bridge | 2020 | 1.23 | 2019 | 2021 | |
| Structure design | 2021 | 1.59 | 2020 | 2023 | |
| Standardization | 2021 | 1.27 | 2021 | 2023 | |
| Seismic Performance | 2018 | 1.18 | 2021 | 2023 | |

The research also focuses on WOS database's keywords from 2014 to 2023, which is shown in Table 3. The same as CNKI, seismic design is also a popular topic, but in CNKI it became an upsurge from 2018 while in WOS it ended up in 2018. It is seldom mentioned after 2018 because it has been a mature technology. Embodied energy has a relatively higher strength. It refers to embodied carbon emission energy.

**Table 3.** Keywords Analysis Based on WOS from 2014 to 2023

| Keywords | Year | Strength | Begin | End | 2014 - 2023 |
|---|---|---|---|---|---|
| Energy efficiency | 2014 | 11.71 | 2014 | 2018 | |
| Seismic design | 2014 | 3.39 | 2014 | 2018 | |
| Construction management | 2014 | 3.14 | 2014 | 2015 | |
| Building envelope | 2014 | 3.08 | 2014 | 2017 | |
| Building construction | 2014 | 2.99 | 2014 | 2019 | |
| Building materials | 2015 | 3.76 | 2015 | 2019 | |
| Life cycle assessment | 2015 | 3.08 | 2015 | 2019 | |
| Embodied energy | 2016 | 5.64 | 2016 | 2018 | |
| Fire resistance | 2016 | 4.1 | 2016 | 2020 | |
| Hygrothermal performance | 2016 | 3.85 | 2016 | 2017 | |
| Framework | 2016 | 2.92 | 2016 | 2019 | |
| Carbon | 2017 | 3.41 | 2017 | 2019 | |
| Greenhouse gas emissions | 2014 | 3.06 | 2018 | 2019 | |
| Prefabricated structure | 2020 | 3.57 | 2020 | 2021 | |
| Construction waste | 2021 | 3.05 | 2021 | 2023 | |
| Joint | 2021 | 3.05 | 2021 | 2023 | |

The lifecycle method is applied to estimate $CO_2$ emissions, typically measuring the carbon emissions generated during the entire lifecycle of a product or region from cradle to grave due to fuel use, manufacturing, and transportation processes. It has been an upsurge in recent years, and low embodied carbon emission is one of the main reasons that why prefabricated buildings are popular. Structure of prefabricated buildings is frequently mentioned in recent years, which is the same in CNKI. It should be noticed that "joints" of prefabricated buildings is a branch of structure, and

whether the joints of a prefabricated building are reliable determines the building's safety. Therefore, worldwide researchers began to improve prefabricated buildings' structure nowadays, revealing prefabricated buildings, as a new construction technology, are toward maturity.

## 4. Conclusion

Based on CiteSpace software, this paper analyzes the literature on prefabricated buildings in WOS and CNKI database in time order, publication countries and research hotspots. The latest developments and research hotspots of prefabricated construction are investigated, and the following main conclusions are drawn:

(1) The prefabricated building boom will continue for some time, and there will be more and more research conducted worldwide. However, in some countries and regions where prefabricated building research is near saturation or experiencing bottlenecks, such as China, research intensity will remain or decline. China and Australia have already formed the biggest boom in prefabricated building research, and they will be the frontier explorers in this field for decades to come. In the early days of the future, prefabricated building researchers will devote a lot of energy to structural evolution to ensure that the structure of prefabricated buildings is safe and reliable. In addition, it can be noted that standardization has become a hot spot in China recently. Therefore, China will focus on promoting the standardization and universality of prefabricated buildings.

(2) The main problem of prefabricated buildings is structural reliability. The structural unreliability and uncontrollability caused by joint and standardization problems call into question the safety of prefabricated buildings and undermine the inherent advantages of prefabricated buildings in efficient construction. In the future, as these problems are gradually solved, prefabricated construction, as an emerging form of technology, will significantly improve the efficiency and sustainability of human construction.

## Reference

[1] Navaratnam S, Ngo T, Gunawardena T, & Henderson D. Performance Review of Prefabricated Building Systems and Future Research in Australia. Buildings, 2019, 9(2): 38.

[2] Cao X, Li X, Zhu Y & Zhang Z. A comparative study of environmental performance between prefabricated and traditional residential buildings in China. Journal of Cleaner Production, 2015, 109: 131-143.

[3] Shang Z, Wang F & Yang X. The Efficiency of the Chinese Prefabricated Building Industry and Its Influencing Factors: An Empirical Study. Sustainability, 2022, 14(17): 10695.

[4] Hong J, Shen G Q, Li Z, Zhang B & Zhang W. Barriers to promoting prefabricated construction in China: A cost–benefit analysis. Journal of Cleaner Production, 2018, 172: 649-660.

[5] Wikipedia Contributors. CNKI. Wikipedia; Wikimedia Foundation. April 1, 2019. Retrieved on May 7, 2024. Retrieved from: https://en.wikipedia.org/wiki/CNKI

[6] Wikipedia Contributors. Web of Science. Wikipedia. June 29, 2020. Retrieved on May 7, 2024. Retrieved from:https://en.wikipedia.org/wiki/Web_of_Science

[7] Li X, Ma E & Qu H. Knowledge mapping of hospitality research − A visual analysis using CiteSpace. International Journal of Hospitality Management, 2017, 60: 77-93.

[8] Wei J, Li J, Zhao J & Wang X. Hot Topics and Trends in Zero-Energy Building Research-A Bibliometrical Analysis Based on CiteSpace. Buildings, 2023, 13(2): 479.