Bibliometric Analysis of Research Literature on Subway Station Construction Based on CiteSpace

Dehuan Sun[1*], Shuxiang Zhang[1], Wentao Liu[1], Tao Deng[2]

[1]China Communications Construction first highway Engineering Bureau Third engineering Co., LTD, Beijing, China
[2]School of Civil Engineering, Chongqing Jiaotong University, Chongqing 400074 China

*Corresponding author's e-mail address: WH18899319911@126.com

Abstract. In order to systematically analyze the progress and hotspots of subway station construction research, based on the China Knowledge Network (CNKI) database and Web of Science (WOS) database, 756 Chinese and 409 English journal articles were searched from 2005 to 2024. The CiteSpace software was used to construct a knowledge graph for bibliometric visualization and analysis of the current status of research and cutting-edge hotspots in the field of metro station construction from the indicators of the number of publications, countries, authors, institutions and keywords. The results show that chinese research hotspots are mainly distributed in the subway station, surface settlement, construction, deep foundation pit, numerical calculation, while English research hotspots are mainly for remedial measure, model test, numerical modelling, ground loss and so on. The construction of subway stations has gradually formed a process system of construction-monitoring-simulation-control. Future research needs to focus on numerical fine modeling and construction safety risk assessment.

Keywords: subway stations; construction; citeSpace; bibliometrics; knowledge map

1 Introduction

Subway stations are generally built in the city center of high traffic flow. However, the existence of more surrounding buildings and the complexity of underground pipelines often brings the problem of restricted construction sites, which brings great difficulties to the construction of subway stations in terms of technology and safety. With the development of underground works in various geological conditions, the construction of subway stations is characterized by problems such as technical complexity and uncertainty of underground works, which can easily lead to safety accidents[1-5]. Therefore, summarizing and analyzing the research status of subway station construction and grasping the cutting-edge hotspots are of great significance and value for improving construction technology and reducing construction accidents.

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2 Data Source and Research Method

2.1 Data Source

China National Knowledge Infrastructure (CNKI) database and Web of Science (WOS) database were used as a literature search platform, and the search time was set from 2005-1-1 to 2024-6-11. The source category of CNKI database was limited to Chinese periodicals only, and Beida Core, CSCD, EI and SCI platforms were selected for inclusion, with the subway station and the construction as the subject terms for advanced search. After proofreading and checking the retrieved documents manually, a total of 756 journal articles were obtained and exported in Refworks format. WOS database was searched by TS=subway station AND TS=construction, the language was English. The type of literature was selected as Article or Review. Finally, 409 relevant documents were retrieved and proofread and it was exported in txt format by selecting Full Record and Cited References. Finally, the Chinese and English documents were imported into CiteSpace for processing and statistical analysis.

2.2 Research Method

Bibliometrics is widely used to discuss the research development, hotspots and directions of various research fields. Many softwares such as CiteSpace and VOS viewer can visualize the bibliometric data statistics and can present to the scholars in the form of knowledge graph, so that each scholar can more intuitively understand the developmental changes and outlook of a certain academic field. In this paper, CiteSpace 6.3.R1 software was used to calculate the authors and institutions collaborative network of the papers related to the construction of subway stations, analyze the keywords in co-occurrence, clustering and timeline, and draw knowledge map to visualize the statistical results, so as to provide a new way of thinking and reference for the future related research.

3 Research Hotspots and Trends

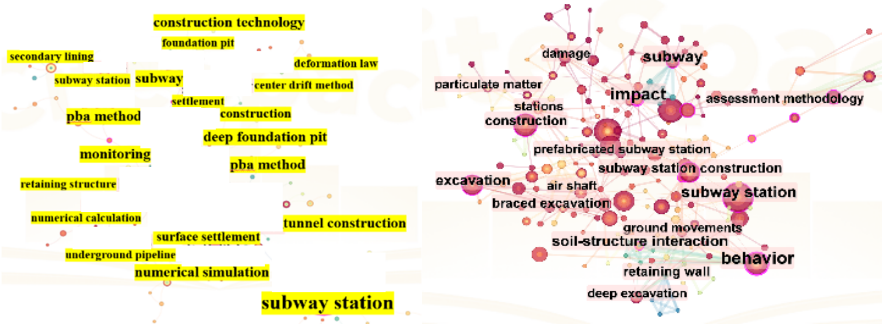
3.1 Research Hotspots

Bibliometric analysis can objectively and quantitatively identify the research hotspots in a certain field, which can help researchers grasp today's mainstream research content and look forward to future research directions.

3.1.1 Keyword Co-Occurrence

It can be seen in Fig. 1, subway station (367 times), numerical simulation (86 times), subway (80 times), construction technology (70 times), and deep foundation pit (64 times) are the keywords with the highest frequency. Similarly, the relevant literature searched in WOS database with Keyword as the network node obtains 279 nodes and

487 links, and the network density is 0.0126. Similar to the research results in Chinese, subway station and numerical simulation are also the most frequent keywords[6-7].



(a) CNKI keyword co-occurrence (b) WOS keyword co-occurrence

Fig. 1. Keyword co-occurrence network mapping

To more accurately represent the relationship and status between keywords, this study listed the co-occurrence frequency and centrality of keywords with co-occurrence frequency greater than 20 in Table 1 (CNKI database) and Table 2 (WOS database). Keyword centrality indicates the strength of the keywords ability to connect the co-occurrence network as a connecting hub.

Table 1. Frequency and centrality statistics of the co-occurrence of Chinese keywords

Rank	Keywords	Frequency	Centrality
1	subway station	367	0.62
2	numerical simulation	86	0.26
3	subway	80	0.39
4	construction technology	70	0.23
5	deep foundation pit	64	0.2
6	surface setlement	43	0.29
7	pha method	38	0.12
8	construction	29	0.25
9	monitoring	25	0.36
10	station	24	0.18

From the keyword centrality, it can be seen that the centrality of the keywords such as tunnel engineering, subway station, subway, monitoring, surface settlement, numerical simulation are ranked in the top position, with the centrality is greater than 0.1. It indicates that the above keywords are the hot topics of concern in the years of 2005-2024, and have gradually formed the process system of construction-monitoring-simulation-control.

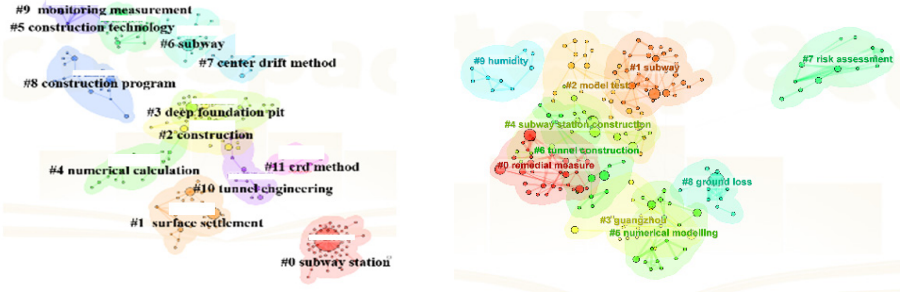
Tab**le 2.** Frequency and centrality statistics of the co-occurrence of English keywords

Rank	Keywords	Frequency	Centrality
1	Subway station	63	0.13
2	Numerical simulation	44	0.05
3	Construction	40	0.10
4	Model	38	0.03
5	Excavation	30	0.16
6	Tunnel	30	0.04
7	Behavior	25	0.24
8	Performance	24	0.05
9	Subway station construction	23	0.18

In the English studies, keywords such as behavior, subway station construction, excavation, and subway station have high centrality and occupy a central position in the research field, but their centrality is generally lower compared to the Chinese literature.

3.1.2 Keyword Clustering

Cluster analysis is a statistical process of grouping different keywords according to certain characteristics, and is widely used to identify hot issues in a particular research area. The keywords are clustered and analyzed in CiteSpace using K-clustering method and LLR algorithm to draw the keyword clustering map of subway station construction (Fig. 2). Meanwhile, the clustering results are quantified and ranked according to the cluster size from high to low, and the results are shown in Table 2.



(a) CNKI keyword clustering (b) WOS keyword clustering

Fig. 2. Keyword clustering network mapping

From Fig. 2, it can be seen that the important index of this clustering, cluster module value Q is 0.8261, and the average profile value of clustering S is 0.9611. According to the CiteSpace help manual, when Q>0.3, the clustering profile network is significant. When S>0.5, the clustering profile is reasonable, and when S>0.7, the clustering result is highly credible. The Chinese study Q>0.3 and S>0.7 indicates that the clustering effect is better and convincing. From the clustering results, it can be seen that 12 clusters

are formed for subway station construction. Removing the categories of subway station and construction related to the search terms of this paper, numerical calculation and monitoring and measurement are the mainstream research methods nowadays. Numerical computation and monitoring and measurement are the mainstream research methods nowadays. The construction process combined with monitoring and measurement and numerical analysis can often achieve better results, so that construction personnel can accurately control the construction process. The center drift method and CRD method are the two most used construction methods. Meanwhile, deep foundation excavation is often unavoidable in subway station construction, so deep foundation and surface settlement are also highly frequent clustering categories.

From Fig. 2, it can be seen that the cluster module value Q is 0.8373, and the average profile value S is 0.9174. The clustering mapping network is significant, and the clustering results are highly reliable. The English literature is consistent with the Chinese studies in terms of the categories of numerical modeling, surface settlement, and subway station, but new clustering categories such as remedial measure, Guangzhou, and risk assessment appear in the English studies. The term Guangzhou indicates that the researchers have carried out a lot of research on the construction of urban subway stations in Guangzhou, and remedial measure reflects the research direction of disposal measures for engineering construction diseases. risk assessment indicates that the researchers have paid attention to the safety aspect, and the risk assessment of the engineering construction process is also a very important part.

3.2 Trends In Research Development

The emergent keywords refer to the research content that has a sudden increase in the frequency of co-occurrence in a period of time, which can show the change of research hotspots in a field and can reveal the development trend of the research frontier hotspots in the field. Utilizing the Buretness function of CiteSpace software for keyword emergence mining, the keyword emergence graph is depicted in Fig. 3.

As can be seen in Fig. 3(a), the emergence of the terms construction, shallow excavation and deep foundation pit in 2006-2010 indicates that the researchers mainly focus on the construction method and the construction process itself in this period of time. In 2011-2015, the construction process of subway stations is mainly controlled by monitoring the settlement deformation. With the rapid development of computer technology in recent years, the terms numerical simulation, numerical computation and risk assessment have emerged after 2021. It shows that numerical analysis has become a widely used research method by researchers. Refined modeling can effectively simulate the process of metro station construction, which can be used to conduct scientific research in related fields and assist on-site construction. Researchers have also gradually shifted from the study of construction technology to construction safety risk assessment.

As depicted in Fig. 3(b), in terms of the timing of emergence, keyword emergence started in 2016, which is consistent with the fact that the annual number of articles is in a period of rapid increase from 2016-2024. In contrast, keyword emergence did not occur during the initial development phase (2005-2015), when the number of articles was very small. Before 2020, international scholars mainly focused on deep foundation

pits and construction technology and management. The brief appearance of the emergent term Shanghai indicates that there was a large number or significant special subway station construction in the region at that time. After 2020, the research hotspot gradually changes to the prediction of construction deformation, in which settlement and soil are still in the emergent state. In terms of the emergence degree, deformation and design have the highest emergence degree, with the emergence intensity of 4.23 and 3.69, respectively.

(a) CNKI keyword emergence (b) WOS keyword emergence

Fig. 3. Keyword emergence map

4 Conclusions

The hotspots of Chinese research are mainly distributed in the surface settlement, construction, deep foundation pit and numerical calculation of subway station. While the hotspots of English research are mainly remedial measure, model test, numerical modelling, ground loss. The construction of subway stations has gradually formed a process system of construction-monitoring-simulation-control. Future research should focus on numerical modelling and construction safety risk assessment.

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