Research on International Engineering Safety Management Research Based on Knowledge Map

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Abstract. In recent years, the safety and health of the project has become a key issue for the in-depth study of the construction industry, in order to demonstrate the current status of international engineering safety management in the country (regions) and researchers, and the analysis results based on research hotspots and research frontiers. The management and research cooperation researched the future development trend and made a reasonable forecast. The visualization and statistics functions of CiteSpace were used to conduct research on the field of engineering safety management, and a visual knowledge map was obtained. Research on the knowledge map shows that: 1) International research on engineering safety management is mainly concentrated in developed countries such as Europe and the United States. Many countries have established cooperation with the United States, while cooperation between other countries is relatively scattered, showing a clear "no scale" phenomenon; 2) The focus of international engineering safety management research 2003-2017 focuses on the cultural and technical aspects; 3) The research hotspot of engineering safety management from 2003 to 2017 can be divided into five phases. The current research hotspot is the safety management at the construction site and the risk control before construction.

1. Introduction

As one of the three core objectives of project management, project safety management means that project managers carry out all-directional and multi-level security control over the entire life cycle of a project according to relevant laws and regulations and various rules and regulations within the company. Under the premise of ensuring the safety of field workers, the maximum benefit of the project is realized. In the field of engineering safety management, developed countries such as Europe and the United States started earlier than China, it was in 2004, Vastert and Gelder¹ evaluated the risk management capability of large design and construction contractors, and risk management and risk analysis are important tools to ensure the profitability of the project to highlight the importance of engineering safety management. Afterwards, Tam, Choudhry and Suraji conducted research on the high-risk nodes in the construction process and the key factors that induce safety accidents, the construction site environment, and the responsible subjects of construction accidents, respectively, and enriched the research content of engineering safety management²-⁵. In 2017, Scheepbouer et al. through the investigation of the latest research on digital construction in 2000-2016, the security technologies of digital buildings are classified, the research trends in this field are determined, and their role in accident prevention is analysed⁶. In terms of domestic affairs, Yangliqiong and others study the quantitative analysis of construction safety risk, puts forward the method of building safety risk assessment based on binary decision map, and
provides scientific basis for the establishment of safety risk control measures[7]. Therefore, this paper focuses on obtaining the research clues of engineering safety management from a large number of literature databases, and reasonably predicts the future research direction of this field.

Considering that the article published in the Web Of Science database has a rich level of research topics, the selection process is rigorous and orderly, and it plays an extremely important role in knowledge discovery and scientific research analysis. In the course of research and cooperation on international engineering safety management, this paper selects the related papers on the core collection of Web Of Science. Using CiteSpace V software to carry out national(regional) co-occurrence analysis, author co-occurrence analysis, literature co-citation analysis, journal co-citation analysis, research hotspot analysis, and research frontier analysis, respectively. In order to clarify the knowledge subject and knowledge foundation in the field of engineering safety management research, grasp the development context of engineering safety management research, deeply understand the research hotspot and frontier of the subject field, and provide reference for the future development trend of engineering safety management research.

2 Data acquisition and method

2.1 Data collection

This article collects foreign language literature data in the field of engineering safety management from Web of Science(WoS), because Construction safety management specifically includes safety management evaluation, technological means innovation, and theoretical knowledge deepening. Therefore, the search theme is "Construction management" and the time span is 2003-2017. By clicking the search key, 1,587 document data were eventually obtained and saved to a folder in the format of Download_xx.txt for subsequent analysis. In order to analyse the trend in the volume of construction safety management issued in WoS, the data obtained from WoS are shown in Figure 1 by year.

As can be seen from figure 1, the international literature on construction safety management has shown an overall upward trend from 2003 to 2017, with the lowest volume in 2003 and the highest in 2017. The volume of documents issued has roughly gone through three stages. The first stage was from 2003 to 2007. This stage is characterized by a relatively small amount of documents issued each year, an average annual amount of documents issued less than 50, and a balanced number of documents issued each year. 2008-2014 is the second stage, and the volume of documents issued at this stage has been
greatly improved. The average annual volume of documents issued is more than 90, which is close to 2 times that of the first stage. The third stage is from 2015 to 2017, and the volume of documents issued during this period has grown by leaps and bounds. The number of documents issued in each year has been more than 210, and the average annual amount of documents issued is 236. This shows that the international attention to construction safety management is increasing year by year, and it also shows that the international attention to engineering safety is increasing. The change of this trend makes us pay more attention to engineering safety management. Through the change of this trend, the importance of cooperative research on engineering safety management is further explained.

2.2 Research technique
In the process of visualizing specific subject areas, Chinese researchers use more scientific mapping tools, including Hiscite in Garfield, SCI 2 in Indiana University, VOSViewer in Leiden University in the Netherlands, and Chenchaomei in the Netherlands. CiteSpace developed and general network visualization software Pajek and Gephi. Compared to other types of visualization tools, CiteSpace can not only present the evolution path of the research field in the form of a visual knowledge map, clarify the potential knowledge framework behind massive data, but also help researchers grasp the development of disciplines in the time dimension. The main line of research, Understanding the distribution characteristics of research hotspots and research frontiers, reasonably predicting the future development of the research area, and having the role of knowledge navigation, belongs to the category of scientific measurement. Considering the research purpose of this paper, this paper uses the information visualization software CiteSpace V to visually analyze the research cooperation status in the field of engineering safety management research[16]. This study mainly uses CiteSpace V software to use its country(regional) co-occurrence analysis, author co-occurrence analysis, literature co-citation analysis, journal co-citation analysis, etc. to combine its powerful visualization and statistical functions. Intuitively understand the current situation of engineering safety management scientific research cooperation and research hot spot and development frontier.

3 Visual analysis of cooperative research on engineering safety management

3.1 Analysis of knowledge subject in engineering safety Management Research
The subject of knowledge in the field of engineering safety management research refers to scientific research institutions or researchers who carry out knowledge excavation, scientific discovery, and promote the development of the subject field in this field. According to the granularity of the subject, the subject of knowledge includes the countries(regions), institutions, and authors who publish related papers or monographs. By analyzing the knowledge subjects in the field of engineering safety management research, we can grasp the research status of engineering safety management field and related disciplines at multiple levels, multiple angles, and comprehensively.

3.1.1 National(regional) co-occurrence analysis. When analyzing the knowledge subjects in the field of engineering safety management research from the macro level, the country or region is used as the analysis unit. In CitySpace, the key node is selected as "Country" to obtain a national(regional) cooperation knowledge map. The results show that there are 46 nodes, 108 connections, and a network density of 0.1043. Each node represents a country(region). The size and color of the node reflect the frequency and time of sending messages in different countries(regions). It was found that the nodes representing the United States are the largest and purple, which shows that the United States occupies a dominant position in this discipline, while the strength of cooperation between other countries(regions) is not outstanding, and there is a clear "no scale" phenomenon.

3.1.2 Co-existing analysis of authors. The author's co-analysis is to discuss the cooperation of knowledge subject in the field of engineering safety management based on microcosmic level. By carrying out the co-analysis of the authors, we can clarify the academic cooperation links that different
researchers in this field construct at the individual level, grasp the knowledge network distribution of the subject of academic research, and further clarify the core authors and key knowledge subjects of the research field.

Figure 2 shows the key researchers in the field of global engineering safety management in 2003-2017 and their partnership. Looking at the upper left corner of Figure 2, it is found that there are 267 nodes (N) and 200 lines (E) in the graph, and the density (Density) is 0.0056, that is, in 2003-2017 years, there are 267 authors worldwide (frequency ≥5) involved in the field of engineering safety management research work. However, the strength of cooperation between different authors is not ideal, which can’t effectively integrate the advantages of scientific research resources of different researchers. In order to show more clearly the distribution of knowledge subjects in the time dimension of global engineering safety management research field at the micro level, and the corresponding research output, this study details the author’s name and the time of the first publication in the field of global engineering safety management research for more than 10 times in 2003-2017 years. The details are shown in table 1.

![Fig. 2 Map of collaborative knowledge of authors in the field of global engineering safety management research](image)

**Table 1** Statistical table of authors of Gaofawen frequency in the field of global engineering safety management research

| No. | Author        | Frequency | Publish | No. | Author          | Frequency | Publish |
|-----|---------------|-----------|---------|-----|-----------------|-----------|---------|
| 1   | Li H          | 19        | 2012    | 4   | Rubio-Romero JC| 13        | 2013    |
| 2   | Chan APC      | 18        | 2010    | 5   | Teizer J        | 12        | 2013    |
| 3   | Hallowell MR  | 15        | 2012    | 6   | Gambatese JA    | 11        | 2009    |

In 2003-2017, the high-yielding authors of the Global Engineering Safety management research include Li H, Chan APC, Mr. Hallowell, Lubio Romes, Fangdongping, Ding, etc., which are the main research forces in the field of global engineering safety Management, in 2003-2017 compared with other authors published more high-quality papers, with a high level of scientific research output and knowledge contribution rate, is to promote the development of the subject field and improve the indispensable research force. Their research direction and content also reflect the direction of international engineering safety management research to some extent.

3.2 Co-citation analysis of engineering safety management

In the analysis of the knowledge base in the field of engineering safety management, the paper mainly introduces 2 aspects from the literature and the periodical altogether. Through the analysis of the knowledge base in the field of engineering safety management, it is possible to clarify the development of the subject field and grasp its development direction and the knowledge structure of the whole subject from the whole.
Figure 3 shows the 2003-2017 years of international engineering safety Management Research in the field of literature, the identification of the upper left corner of the knowledge map, found in the graph of total nodes (N) 287, Wired (E) 415, network density (Density) is 0.010 1. Using CITESPACEV to statistically analyze the high cited literature (TOP10) and the High Center degree literature (TOP10) in the field of international engineering safety Management Research in 2003-2017, we found 2003- The top 10 most frequently cited articles in the field of international engineering safety Management Research in the 2017 focus on improving the safety status of construction sites from the cultural level (climate/culture) and technical level (technology), and building a reliable engineering safety management system.

![Knowledge map of international engineering safety management research areas from 2003 to 2017](image)

Fig. 3 Knowledge map of international engineering safety management research areas from 2003 to 2017

3.3 Frontier Analysis of Engineering safety management research
Considering that the frontier of research in a subject field usually manifests itself in the emergence of new keyword and the abnormal change of word meaning, this paper citespace the burst detection function to show the forefront of the research of engineering safety management in the 2003-2017. This function can identify the more frequent changes in keywords, this article defines these keywords as research frontier keywords. With the help of CiteSpaceV’s information visualization function, this paper generates a mutation time zone map of the relevant mutation words in the Subject field in 2003-2017, as shown in Figure 4.
Fig. 4 Map of relevant mutant time zones in the field of international engineering safety management from 2003 to 2017

As shown in Figure 4, the forefront hot spots in the research field of international engineering safety Management in the 2003-2017 have been in dynamic change, and the attention points of researchers in different periods have been emphasized. Specifically, it is divided into 5 time periods for analysis: In 2003-2005, the analysis of occupational safety and risk inducement of construction enterprises and the specific accident prevention measures aroused extensive attention of researchers. In the 2006-2008, researchers focused on the construction of Engineering safety management system from the cultural level; In 2009-2011, the forefront of engineering safety Management Research focuses on the analysis of the potential impact of company size and age structure on the risk of safety accidents, as well as the simulation of the construction process, in advance to predict the occurrence of various types of accidents risk; In 2012-2014, the researchers focused on safety performance analysis of the physical and mental health of engineering personnel; in 2015-2017, the safety management of construction site and the risk control before construction became a new frontier hotspot and research mainstream.

4 Conclusion

1) In the field of engineering safety Management Research area of the country, mainly in Europe and the United States and other developed countries. Among them, the United States and most countries have cooperative relations, in the field of engineering safety management Research in the academic cooperation network occupies an absolute dominant position. The situation of cooperation among other countries is worrying, and the international cooperation shows a clear "scale-free" phenomenon.

2) The top 10 articles in the field of international engineering safety Management Research in the 2003-2017 were mainly focused on improving the safety status of the construction site from the cultural level (climate/culture) and the technical level (technology), and constructing a reliable engineering safety management system. The research hotspot focuses on the analysis of the influence of the three sides on the performance of engineering safety management.

3) The forefront hot spots in the research field of international engineering safety Management in the 2003-2017 have been in dynamic changes, and the attention points of researchers in different periods have focused on each other. The current research hotspot is the safety management of the construction site and the risk control before the construction. In the future, it will be more inclined to construct a complete project safety management system from the cultural level, starting from the behavior subject "people" of safety management, strengthening the safety consciousness, standardizing the construction process, and evaluating all kinds of accident risks beforehand.

References

[1] J. G. Vastert, PHAJM van Gelder, Effectivity of risk management for design & construct projects of large contractors[M]. GODALMING: SPRINGER-VERLAG LONDON LTD,
2004: 481-487

[2] Rowlinson C J S. Institutional determinants of construction safety management strategies of contractors in Hong Kong[J]. Construction Management & Economics, 2014, 32(7-8): 725-736.

[3] Chi S, Han S, Kim D Y, et al. Accident risk identification and its impact analyses for strategic construction safety management[J]. Statyba, 2015, 21(4): 524-538.

[4] Janhonen M, Johanson J E. Role of knowledge conversion and social networks in team performance[J]. International Journal of Information Management, 2011, 31(3): 217-225.

[5] Guo H L, LI H, LI V. VP-based safety management in large-scale construction projects: A conceptual framework[J]. Automation in Construction, 2013, 34(2): 16-24.

[6] YANG Liqiong, LI Shirong, JIA Bin. Construction Safety Risk Assessment Based on Dual Decision Diagram[J]. System engineering theory and practice, 2013(7): 1889-1897.

[7] LI Ying, LI Feng, ZOU Yu, et al. Safety and Quality Assessment of Construction of Prefabricated Concrete Construction[J]. Construction technology, 2016(4): 305-309.

[8] WANG Youguo, WANG Xiudai. Research on the safety risk evaluation of large-scale engineering projects based on Gray-Shapley[J]. Construction technology, 2017(3): 289-292.