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A deep dive into tunnel blasting studies between 2000 and 2023—A systematic review

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ABSTRACT

Tunnel blasting is a common practice used to excavate rock formations. Many academic research articles have emerged and burgeoned in the field of tunnel blasting. These articles are dedicated to investigating objectives such as blasting vibration, rock damage, and vibration energy individually. However, no systematic analysis is conducted to consolidate and analyze the findings from the literature related to tunnel blasting. This study addresses this by offering a systematic review to explore the state of tunnel blasting research. A science mapping approach using bibliometric analysis is employed to examine 144 peer-reviewed journal articles. The review identified the most influential journals, institutions, researchers, and articles on tunnel blasting research, and it also summarizes the research hotspots of tunnel blasting according to the cluster analysis of research keywords. Findings in this review revealed the contribution of two leading journals, three leading institutions, and three leading researchers on the research of tunnel blasting. Moreover, four research keywords, i.e., blasting vibration, numerical simulation, rock damage, and overbreak, were identified as the research hotspots in 2018–2023. Finally, this review also speculated the future research directions/avenues of tunnel blasting, aiming to bring to light the deficiencies in the currently existing research and provide paths for future research.

1. Introduction

Drilling and blasting is a common rock excavation method used in the construction of tunnels and underground structures. The process involves the controlled use of explosives to break up the rock mass and create the desired excavation profile. The success of tunnel rock blasting depends on a range of factors, including the design of the blast, the selection of explosives and initiation systems, and the properties of the rock mass. In recent years, research in the area of tunnel blasting has focused on various aspects, such as the design of blasting patterns, optimization of blast parameters, and other potential environmental impacts (Jiang et al., 2021; Yilmaz and Unlu, 2014). Many studies have investigated the effects of blasting on the stability of surrounding rock formations, the potential for overbreak, and the generation of ground vibrations and noise (He et al., 2023; Jang and Topal, 2013; Mottahedi et al., 2018). Various techniques such as field monitoring and numerical

simulation have been applied to investigate these topics (Jiang and Zhou, 2012).

While there have been many individual studies on tunnel blasting, few studies have provided an overall pattern of tunnel blasting. Individual research efforts, while valuable, often lack a holistic view that synthesizes these disparate findings into a coherent framework. Thus, there is a need for a systematic review that can consolidate and analyze the findings from multiple sources that are relevant to tunnel blasting. A systematic review is a rigorous and transparent method for identifying, selecting, and appraising relevant studies on a particular topic. By providing an unbiased and comprehensive analysis of the existing knowledge, a systematic review can inform future research and practice and identify gaps in the literature (Harris et al., 2014; Wright et al., 2007). Furthermore, the application of science mapping within the systematic review process offers a powerful means to navigate the expansive landscape of tunnel blasting research. Given that a complete

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picture of what has been done and what needs to be done in tunnel blasting is yet to emerge, this study attempts to synthesize relevant research to explore the patterns and praxis in the existing body of knowledge on tunnel blasting.

Science mapping is a useful tool for conducting a systematic review, as it can help researchers identify relevant literature and visualize the connections between different literature (Börner et al., 2003). A science mapping study typically applies a bibliometric or a scientometric analysis method (Hosseini et al., 2018). It primarily comprises several specific phases: data collection analysis, science mapping tools selection, modeling, visualization, and communication of findings (Jin et al., 2019; Liang et al., 2023; Tarekgn Gurmü et al., 2022). Thus, this study uses the bibliometric analysis approach to provide insights into research collaboration networks and research clusters of tunnel blasting. The review work is conducted on 144 peer-reviewed journal articles published from 2000 to 2023. The purposes of this review are to: (1) summarize research on tunnel blasting; (2) highlight the contributed researchers, collaboration networks, and preferred outlets; (3) identify research hotspots through cluster analysis and highlight research gaps; (4) speculate future research directions/avenues. The insights gained from this study of previous literature on tunnel blasting could assist researchers in bridging existing theories and exploring other directions in the near future.

This study is structured with the following sections. Section 2 introduces the approach to conducting this systematic review, as well as the detailed steps in performing the bibliometric analysis. Section 3 first presents the descriptive results of the reviewed articles and then identifies the research hotspots through cluster analysis of research keywords. Section 4 summarizes the main findings of this review and proposes the potential future research directions/avenues of tunnel blasting. Section 5 reports the main conclusions of this review.

2. Research methodology

To synthesize the existing research related to tunnel blasting in scientific literature, this study performed a systematic review to provide a thorough and valuable examination. The systematic review includes five phases:

- 1) The first phase is to conduct a preliminary search according to the drafted keywords.
- 2) The second phase is to filter out the irrelevant terms/publications to refine the search results.
- 3) The third phase is to further manually select the terms/publications that highly conform to the topic, i.e., tunnel blasting.
- 4) The fourth phase is to use the bibliometric tool VOSviewer to analyze the underlying relationship between the obtained results (publications).
- 5) The fifth phase is to conduct a discussion on the publications that were reviewed by the bibliometric analysis.

Fig. 1 illustrates the process of systematic review in this study.

2.1. Publication selection process and criteria

We retrieved the publications tied to tunnel blasting from Web of Science. The publications covered the period 2000–2023 and the database is the Web of Science Core Collection. The process of publication searching is based on guidelines of the preferred reporting items for systematic reviews and meta-analysis protocols (PRISMA-P) (Moher et al., 2015; Shamseer et al., 2015). The preliminary search is according to some tailored keywords/strings listed as follows; meanwhile, Boolean operators in Web of Science such as “OR” and “NOT” are used to filter relevant literature.

- The inclusive keywords/strings are: “tunnel blast*” OR “underground blast*” OR “underground rock blast*” OR “underground rock fragment*” OR “rock tunnel excavation”.
- Necessarily, we also set the exclusion criteria: “surface blast*” OR “quarry” OR “pit” OR “mine*” OR “mining” OR “pile”, to avoid gathering some irrelevant literature.

These keywords/strings are judged by the search engine (SE) in Web of Science in the title, abstract, and keywords of publications. As a result, the preliminary search identified 270 results (the first phase).

Then, we excluded the articles from subjects such as molecular & cell biology, herbicides, telecommunications, optical electronics &

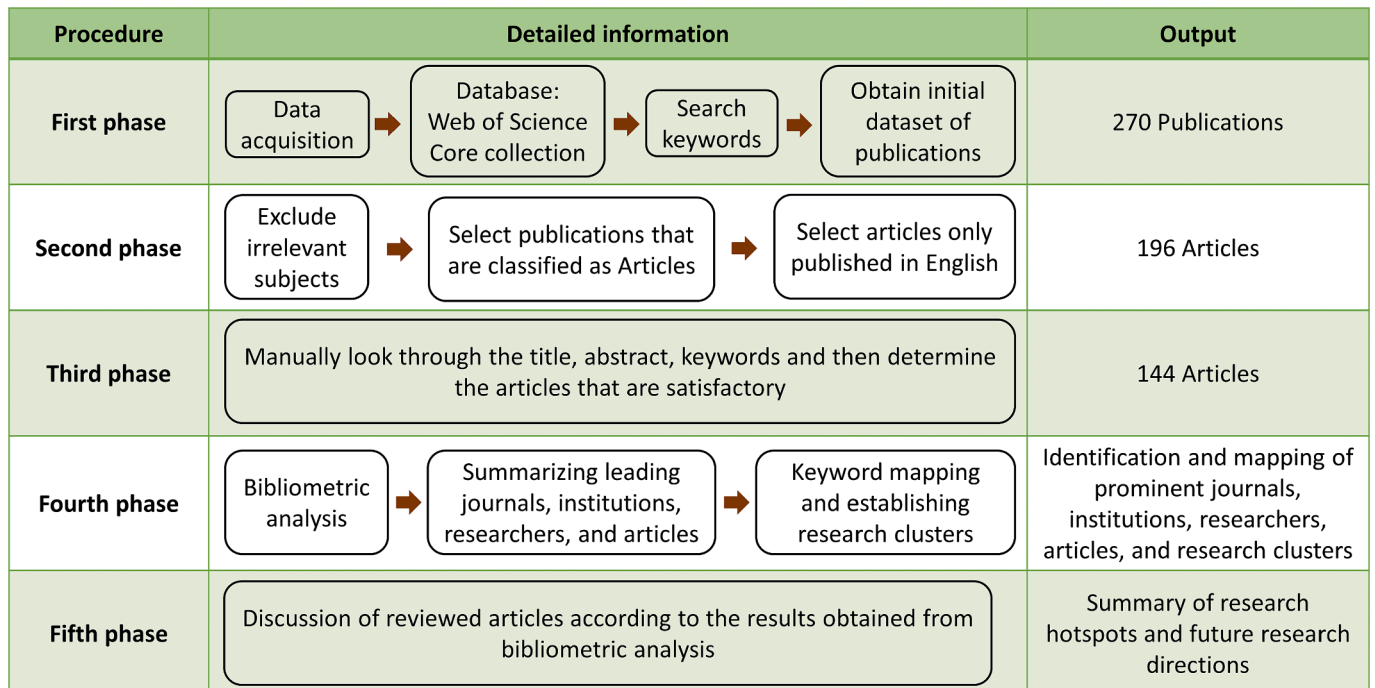


Fig. 1. Flowchart of the systematic review.