JPB REVIEW
INTERNATIONAL JOURNAL OF PROFESSIONAL BUSINESS REVIEW
ISSN: 2525-3654
OPEN ACCESS

QUALITY MANAGEMENT IN BRIDGE DEVELOPMENT: SYSTEMATIC STUDY AND BIBLIOMETRIC ANALYSIS

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ARTICLE INFO

Article history:

Received 18 August 2023

Accepted 22 November 2023

Keywords:

Management System;
Quality;
Bridge Design;
Bibliometrics;
Scientific Advances.

ABSTRACT

Purpose: To provide a bibliometric analysis on quality management in bridge development.

Theoretical framework: The quality management system consists of a set of guidelines based on the PHVA cycle. This system allows controlling the processes where the quality policy must be aligned with the objectives with their respective indicators, in such a way that it can meet the needs and expectations of the client and interested parties (Norma ISO 9001, 2015). The Quality Management System is a way of structuring and organizing operations to direct and ensure the proper functioning of the organization, so that it is more profitable, competitive and adaptable to new and changing market situations (Méndez et al., 2006). Rumiche (2018), a bridge is a work that is built to overcome an obstacle, thus giving continuity to the via ; It is a structure of wood , stone , brick , cement , steel or reinforced concrete that is built so that there is continuity in the transverse width of a path interrupted by the presence of obstacles that are impossible to remove, such as rivers , torrents, arms of the sea and other roads , or to save a unevenness excessive .

Design/Methodology/Approach: The research used bibliometric analysis to determine the relationship between documents, subject areas, authors and institutions. For this, a search was carried out through Scopus, where the bibliometric indicators were analyzed (Noriega et al., 2023). The type of study is descriptive, that is, the results achieved are described, and documentary research of bibliographic references referred to the quality management system in bridges, an analysis is carried out to delve deeper into the most notable aspects obtained in the research process studying the most relevant terms in the findings obtained in the research.

Findings: This work has shown how quality management in the development of bridges can be contemplated from very different points of view through the use of bibliometric tools such as those implemented here, which allow a level of detail that under any other perspective. it would be unlikely. be achieved. It has been particularly significant to note that this global phenomenon has had special significance in those nations that have recently incorporated new scientific findings regarding quality management in the development of modular bridges. This work contributes to the theoretical development of research on quality management in the development of modular bridges due to their efficiency and structural resistance, helps researchers identify the main research aspects and, above all, future lines of research.

Research, Practical & Social implications: The research will serve as a substrate for future research and the social implication is to meet the requirements of the centers

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involved in the development of modular bridges and improve the quality of life of the inhabitants of the region.

Originality/Value: This bibliometric analysis work provides extensive information on the evolutionary process in relation to quality management in the development and design of bridges modular being vital for future research in the field of civil and related engineering.

Doi: https://doi.org/10.26668/businessreview/2023.v8i11.4105

GESTÃO DA QUALIDADE NO DESENVOLVIMENTO DE PONTES: ESTUDO SISTEMÁTICO E ANÁLISE BIBLIOMÉTRICA

RESUMO

Objetivo: Fornecer uma análise bibliométrica sobre gestão da qualidade no desenvolvimento de pontes.

Referencial teórico: O sistema de gestão da qualidade consiste num conjunto de diretrizes baseadas no ciclo PHVA. Este sistema permite controlar os processos onde a política de qualidade deve estar alinhada com os objetivos com os seus respetivos indicadores, de forma a poder satisfazer as necessidades e expectativas do cliente e partes interessadas (Norma ISO 9001, 2015). O Sistema de Gestão da Qualidade é uma forma de estruturar e organizar as operações para dirigir e garantir o bom funcionamento da organização, para que esta seja mais lucrativa, competitiva e adaptável às novas e mutáveis situações de mercado (Méndez et al., 2006). Rumiche (2018), ponte é uma obra que se constrói para superar um obstáculo, dando assim continuidade à via; É uma estrutura de madeira, pedra, tijolo, cimento, aço ou concreto armado que é construída de forma que haja continuidade na largura transversal de um caminho interrompido pela presença de obstáculos impossíveis de remover, como rios, torrentes, braços de mar e outras estradas, ou para salvar um desnível excessivo.

Desenho/Metodologia/Abordagem: A pesquisa utilizou análise bibliométrica para determinar a relação entre documentos, áreas temáticas, autores e instituições. Para isso, foi realizada uma busca através do Scopus, onde foram analisados os indicadores bibliométricos (Noriega et al., 2023). O tipo de estudo é descritivo, ou seja, são descritos os resultados alcançados, e pesquisa documental de referências bibliográficas referentes ao sistema de gestão da qualidade em pontes, é realizada uma análise para aprofundar os aspectos mais notáveis obtidos no processo de pesquisa estudando os termos mais relevantes nos achados obtidos na pesquisa.

Resultados: Este trabalho mostrou como a gestão da qualidade no desenvolvimento de pontes pode ser contemplada sob pontos de vista muito diferentes através da utilização de ferramentas bibliométricas como as aqui implementadas, que permitem um nível de detalhe que sob qualquer outra perspectiva. seria improvável. ser alcançado. Foi particularmente significativo notar que este fenómeno global teve um significado especial nas nações que incorporaram recentemente novas descobertas científicas relativas à gestão da qualidade no desenvolvimento de pontes modulares. Este trabalho contribui para o desenvolvimento teórico de pesquisas sobre gestão da qualidade no desenvolvimento de pontes modulares devido à sua eficiência e resistência estrutural, auxilia os pesquisadores a identificar os principais aspectos de pesquisa e, principalmente, futuras linhas de pesquisa.

Implicações de pesquisa, Práticas e Sociais: A pesquisa servirá de substrato para pesquisas futuras e a implicação social é atender às necessidades dos centros envolvidos no desenvolvimento de pontes modulares e melhorar a qualidade de vida dos habitantes da região.

Originalidade/Valor: Este trabalho de análise bibliométrica fornece ampla informação sobre o processo evolutivo em relação à gestão da qualidade no desenvolvimento e dimensionamento de pontes modulares sendo vital para futuras pesquisas na área da engenharia civil e afins.

Palavras-chave: Sistema de Gestão, Qualidade, Projeto de Pontes, Bibliometria, Avanços Científicos.

GESTIÓN DE CALIDAD EN EL DESARROLLO DE PUENTES: ESTUDIO SISTEMÁTICO Y ANÁLISIS BIBLIOMÉTRICO

RESUMEN

Propósito: Proporcionar un análisis bibliométrico sobre la gestión de la calidad en el desarrollo de puentes.

Marco teórico: El sistema de gestión de la calidad consta de un conjunto de lineamientos basados en el ciclo PHVA. Este sistema permite controlar los procesos donde la política de calidad debe estar alineada con los objetivos con sus respectivos indicadores, de tal manera que pueda satisfacer las necesidades y expectativas del cliente y partes interesadas (Norma ISO 9001, 2015). El Sistema de Gestión de la Calidad es una forma de estructurar y organizar las operaciones para dirigir y asegurar el buen funcionamiento de la organización, de modo que sea más rentable, competitiva y adaptable a las nuevas y cambiantes situaciones del mercado (Méndez et al.,

2006). Rumiche (2018), un puente es una obra que se construye para superar un obstáculo, dando así continuidad a la vía; Es una estructura de madera, piedra, ladrillo, cemento, acero u hormigón armado que se construye de manera que haya continuidad en el ancho transversal de un camino interrumpido por la presencia de obstáculos imposibles de eliminar, como ríos, torrentes, brazos de mar y otros caminos, o para salvar un desnivel excesivo.
Diseño/Metodología/Enfoque: La investigación utilizó análisis bibliométrico para determinar la relación entre documentos, áreas temáticas, autores e instituciones. Para ello se realizó una búsqueda a través de Scopus, donde se analizaron los indicadores bibliométricos (Noriega et al., 2023). El tipo de estudio es descriptivo, es decir, se describen los resultados alcanzados, y se realiza una investigación documental de referencias bibliográficas referidas al sistema de gestión de la calidad en puentes, se realiza un análisis para profundizar en los aspectos más destacables obtenidos en el proceso de investigación estudiado. los términos más relevantes en los hallazgos obtenidos en la investigación.
Hallazgos: Este trabajo ha demostrado cómo la gestión de la calidad en el desarrollo de puentes puede ser contemplada desde muy diferentes puntos de vista mediante el uso de herramientas bibliométricas como las aquí implementadas, que permiten un nivel de detalle que bajo cualquier otra perspectiva. sería poco probable. ser logrado. Ha sido particularmente significativo notar que este fenómeno global ha tenido especial significado en aquellas naciones que recientemente han incorporado nuevos hallazgos científicos respecto a la gestión de la calidad en el desarrollo de puentes modulares. Este trabajo contribuye al desarrollo teórico de la investigación sobre la gestión de la calidad en el desarrollo de puentes modulares debido a su eficiencia y resistencia estructural, ayuda a los investigadores a identificar los principales aspectos de investigación y, sobre todo, líneas de investigación futuras.
Investigación, Implicaciones Prácticas y Sociales: La investigación servirá como sustrato para futuras investigaciones y la implicación social es satisfacer los requerimientos de los centros involucrados en el desarrollo de puentes modulares y mejorar la calidad de vida de los habitantes de la región.
Originalidad/Valor: Este trabajo de análisis bibliométrico proporciona amplia información sobre el proceso evolutivo en relación a la gestión de la calidad en el desarrollo y diseño de puentes modulares siendo vital para futuras investigaciones en el campo de la ingeniería civil y afines.

Palabras clave: Sistema de Gestión, Calidad, Diseño de Puentes, Bibliometría, Avances Científicos.

INTRODUCTION

Quality is a set of characteristics aimed at providing value through the satisfaction of customer and interested party expectations (Organismo internacional Normalización ISO, 2015); Therefore, quality management is the set of tools used to detect deviations in processes, products and services.

The purpose of quality management is considered to build organizational systems so that customers and interested parties can satisfy their expectations and needs regarding the quality of products, goods or services. Likewise, quality management is referred to the establishment of (Aguado, García, Malpartida, & Garivay, 2022)strategies that entail to the competitiveness of any organization generated through competitive advantages (Araujo, Orellana, Cortéz, & Zambrano, 2020).

Under the design study of metal bridges, this is a structure or set of parts joined together; These can form a body, a shape or a whole, intended to withstand the effects of the forces that act on the body. In this sense, a metallic structure is made mainly of steel, that is, more than 80% of its parts are made of steel. steel and must meet three basic conditions: rigidity, stability and resistance (Rumbo minero, 2016). Their characteristics are easy transportation in pieces

and the speed with which assembly can be carried out, presenting benefits of saving time and space (Rumbo minero, 2019). Metal structures are designed so that they can resist both vertical and horizontal actions; For example, we can see how the bars of metal structures are involved in the construction of bridges since the compression and bending stress points are completely different (Quispe, 2022).

LITERATURE REVIEW

In this regard, the research background is presented as: Ruiz and Carhuaricra (2020) their objective was to implement a quality management system based on the ISO 9001:2015 standard for the La Unión Consortium. The study was of an explanatory level, of an applied type, with a quasi-experimental design. The population and sample were all production processes. Direct observation and interview were applied. The instruments they used were the interview guides, a questionnaire on compliance with the ISO 9001:2015 standard. It was concluded that the design and implementation of a Quality Management System based on the ISO 9001:2015 Standard aligned with the organizational objectives of the La Unión Consortium, satisfactorily achieves an efficiency of 92%, improving quality standards and quality management. organization.

Also in a study, Deza (2020) implemented a GIS for the improvement of processes in the Tambomayo construction project of the company San Martín Contratistas Generales SA The study was of an applied type, descriptive level, with a non-experimental design. The population was composed of 18 support processes, 5 operational processes and 4 directional processes. Purposive sampling was carried out to cover the entire population under study. The interview and survey were applied. The instrument used was the checklist based on ISO 9001. It was concluded that, with the study, it was achieved that the implementation of the GIS improved the organization's processes in quality issues by 30.77%.

Likewise, Torres (2019) proposed an improvement in the quality management system based on the International Standard ISO 9001:2015 so that the metalworking company EMC SRL improves the quality of its products and/or services to satisfy the needs of Your clients. The study was explanatory level, applied in purpose and with a non-experimental design. The population and sample were all the personnel who work in the different areas of the metalworking company EMC. SRL Direct observation and documentary analysis were applied, the instruments used were the unstructured interview and the structured questionnaire. It was concluded that the quality management system was improved based on the international

standard ISO 9001:2015 so that the metal mechanics company EMC SRL optimized the quality of its products and/or services for the satisfaction of its customers.

Likewise, Beltrán and Roncal (2018) implemented the quality management system based on the ISO 9001:2015 standard, which affects the level of customer satisfaction of the Consortium. The study was of applied type and non-experimental design. The population was the staff of the central office of the DCDS Consortium (27 workers), who were considered internal clients. The survey, interview and field observation were applied, the instruments were the structured questionnaire and an observation guide. It was concluded that, by implementing the quality management system based on the documentary structure required by the ISO 9001:2015 Standard of the DCDS Consortium, operation was improved and the quality of services was ensured. 79% was achieved compared to 31% in the initial diagnosis stage.

In the same way, Pacheco (2021) implemented the Quality Management System applying the ISO 9001:2015 Standard to improve the administrative management of the company Naylamp Ingenieros SAC. The study was of an applied type, with a correlational scope, non-experimental design, descriptive and documentary. The population and sample were 25 workers from 3 offices: projects, quality and administration. Observation and survey were applied, the instruments used were the checklist and a questionnaire. It was concluded that, with the implementation of the quality management system applying the ISO 9001:2015 Standard, the administrative management of the company Naylamp Ingenieros SAC was improved by 26%.

In the research by Valladares (2019), the main characteristics of quality management and competitiveness of MYPES in the commerce sector in the metal carpentry sector were determined. The study was descriptive, with a quantitative level and non-experimental design. The survey was applied and the instrument was a research questionnaire. The population and sample in the quality management and competitiveness variable were finitely known. The results were that 67% achieved growth in their company and 57% consider that new products are always acceptable in the market and of better quality than the competition. It was concluded that the principles of quality management and customer-oriented organization, radical decision-making based on facts and the advantages of competitiveness in MYPEs in the commerce sector in the carpentry sector contributed to the implementation of modern machinery and equipment. job.

In this sense, Castillo and Rivas (2018) determined the influence of the implementation of a process management model on the competitiveness of Charlie's Chicken. The study was of

an applied type, with an experimental design. The population and sample were 385 respondents. The interview and a survey were applied, the instruments used were the interview guide and the questionnaire. It was concluded that the Operational Process Management Model significantly influences the competitiveness of Charlie's. Chicken, this was evidenced in the increase in sales income by 18% for the first year and in the reduction of the representativeness of costs over sales by 5%, ensuring better results at an annual level.

Likewise, Ortiz (2018) aimed to determine, describe and analyze the main characteristics of quality management and competitiveness of MYPES in the service sector in the restaurant sector in the center of Tumbes. The study was descriptive level and had a non-experimental design. The population was 32 MYPES and the sample was 15 MYPES. The survey was applied and the instrument used was the questionnaire. It was concluded that by describing the characteristics of quality management, this contributed to MYPES carrying out good quality management in the restaurant sector.

Similarly, Oviedo (2017) aimed to determine how the implementation of the ISO 9001:2015 Quality Management System influences the improvement of the competitiveness of the company Gas Domiciliario del Perú SAC in the district of San Isidro. The study was of an applied type, with an explanatory level and a quasi-experimental design. The population and sample were 40 workers from the different areas of the company Gas domiciliario del Perú SAC, in the district of Chincha Alta. The survey and registration were applied, the instruments were the questionnaire and the registration form. It was concluded that, due to establishing measurement methods and work guidelines where all organizational links work together and under the same objectives, it is possible to improve customer satisfaction, competitiveness, profitability, plurality of customers, service designs. , analysis methods and internal evaluation.

Likewise, Rodríguez (2016) aimed to know the characteristics of quality management and competitiveness of MYPES in the sale of household appliances in the Juanjuí district. The study had a non-experimental design with a descriptive level. The population was the owners of eight MYPES in the service sector in the commerce sector, and the sample was six microenterprises. The survey was applied and the instrument was the questionnaire. It was concluded that 100% of MYPES are formal, 50% have been in the market for more than four years and 100% affirm that Quality Management contributed to improving business performance.

ISO 9001:2015 is an international standard for quality management systems developed by the International Organization for Standardization (ISO). This version was published on

September 23, 2015. Organizations have a period of three years to adapt your system to standard. This standard is applicable to all types of organizations regardless of their size, activity or whether they are public or private. It is focused on homogenizing the quality standards of the various products and services in such a way that allows it to satisfy the needs and expectations of its clients and interested parties; therefore, this becomes a competitive advantage for the organization (Isotools Excellence, s.f.).

The quality management system consists of a set of guidelines based on the Deming cycle PHVA. This system allows controlling the processes where the quality policy must be aligned with the objectives with their respective indicators, in such a way that it can meet the needs and expectations of the client and interested parties (Norma ISO 9001, 2015). It is a set of interrelated processes aimed at providing quality products and services to satisfy the needs and expectations of customers and the organization (Gutiérrez, 2018). It is part of the strategic management of the organization and is aimed at satisfying the needs and expectations of the client and interested parties (Chavarría, 2018). It is a set of interrelated standards aimed at satisfying the needs and requirements of the organization (Acosta, 2019). It is a standardized system that documents the processes to produce quality goods and services and meet customer and stakeholder requirements (Coaquira, 2020).

In this sense, the improvement of processes in organizations must be promoted based on the establishment of regulatory guidelines that encourage the search for new strategies that basically respond to the creation of value (Reyes et al, 2022). Likewise, the importance of quality is crucial in technological improvement and innovation both internally and externally (Zeng et al., 2017). Quality management systems help organizations achieve success, encourage the use of tools, and improve the organizational capabilities of employees (Antunes et al., 2017).

In order to implement a quality management system in accordance with the ISO 9001:2015 standard, you must know that it is structured in ten chapters, the first three informative referring to the scope, normative references, terms and definitions, and the remaining seven. correspond to the requirements to implement and maintain the quality management system. To identify the requirements that are mandatory, the term must is used; the requirements are applicable according to the type of organization and depend on the type of business. The structure is made up of an introduction and ten chapters; which in turn are made up of:

Table 1. Structure of the Quality Management System

Chapter	Qualification	Description
I	Object and field of application.	Size the scope of the standard.
II	Normative references.	They indicate the documents necessary for the application of the standard.
III	Terms and definitions.	Use the standard in order to make it completely understandable.
IV	Organization context.	It indicates the actions that must be carried out in the organization to guarantee the success of the quality management system by establishing the internal/external contexts, needs and expectations, determining the scope of the quality management system, establishing processes and documentation.
V	Leadership	Indicates the involvement of senior management in the quality management system, ensuring that the requirements are integrated into the processes and that the objectives must be aligned with the organization's strategies. In addition, the quality management system must be accessible and communicated, maintained and understood by all parties.
VI	Planning	Indicates the actions to determine risks/opportunities, these must be controlled, managed, and communicated throughout the organization, the need to establish quality objectives and planning changes that must be carried out systematically must also be established.
VII	Medium	Indicates requirements for resources, competence, awareness, communication and documented information.
VIII	Operation	Indicates the requirements for planning and control, as well as for production and services from conception to delivery.
IX	Performance evaluation.	It serves to measure and evaluate the quality management system, ensuring that it is effective and that it helps you continually improve.
X	Improvement	It indicates that organizations determine and identify opportunities to continually improve the quality management system, that is, look for opportunities to improve processes, products or services that allow the organization to satisfy customer needs and expectations.

Source: (Norma ISO 9001, 2015)

MATERIAL AND METHODOLOGY

Type of Research

The research used bibliometric analysis to determine the relationship between documents, subject areas, authors and institutions. For this, a search was carried out through Scopus, where the bibliometric indicators were analyzed (Noriega et al., 2023). The type of study is descriptive, that is, the results achieved are described, and documentary research of bibliographic references referred to the quality management system in bridges, an analysis is carried out to delve deeper into the most notable aspects obtained in the research process studying the most relevant terms in the findings obtained in the research.

Design of Research

The existing data sources in the scientific literature using various approaches for research and tools for data analysis. Bibliometric studies are carried out with data provided by

important databases such as Scopus, because this database includes a greater number of journals (Noriega et al., 2023). Since the object of the research is specifically quality management, the following search criteria were used: ((bridge) AND (quality control system) AND ((bridge) AND (quality management)) AND ((bridge) AND (QA)).

Variables and Operationalization

Conceptual Definition: Quality Management

The quality management system consists of a set of guidelines based on the PHVA cycle. This system allows controlling the processes where the quality policy must be aligned with the objectives with their respective indicators, in such a way that it can meet the needs and expectations of the client and interested parties (Norma ISO 9001, 2015). The Quality Management System is a way of structuring and organizing operations to direct and ensure the proper functioning of the organization, so that it is more profitable, competitive and adaptable to new and changing market situations (Méndez et al., 2006).

Operational Definition: Quality Management

A management system is made up of a set of standards, parameters, processes, procedures and techniques that are implemented in an organization with the purpose of improving efficiency through the implementation of optimization structures that will make it possible to raise its level of productivity.

Perdomo et al. (2006) point out that QMS have a hard and a soft dimension. The hard dimension involves formal aspects of the organization such as standardization and control. The soft dimension refers to the human or social elements that intervene in the implementation of the QMS such as the leadership and philosophy of senior management, the support of the supplier to the employee training and increased interaction with employees and customers.

Conceptual Definition: Bridge Development

Rumiche (2018) indicates that , a bridge is a work that is built to overcome an obstacle, thus giving continuity to the via; It is a structure of wood, stone, brick, cement, steel or reinforced concrete that is built so that there is continuity in the transverse width of a path interrupted by the presence of obstacles that are impossible to remove, such as rivers , torrents, arms of the sea and other roads , or to save a unevenness excessive.

Operational Definition: Bridge Development

Rumiche (2018) indicates that, a bridge predesigned and prefabricated formed by modules or components, based on high resistance steel, with a standard dimension call panel, can be easily mounted on a large number of configurations. Its easy transportation and installation without the need for skilled labor makes it one of the best systems around of the world.

Population, Sample and Survey

Population

The study consisted of scientific literature obtained from the Scopus database, through search equations for informative material in scientific articles, specialized texts, research works and data analysis (Carrasco, 2028).

Sample

The study sample was made up of 561 research articles obtained from the Scopus database, with the purpose of carrying out the respective bibliometric analysis (Pino, 2018).

Sampling

The sampling covered February 25, 2023 and the selected study period was 63 years, from the first article published on the topic in 1960 to those published in 2022, resulting in 561 documents. This sample only included scientific research articles.

Data Collection Techniques and Instruments

The data consisted of scientific works on quality management in the development of modular bridges. In this regard, a bridge is an engineering work whose function is to support traffic vehicular, pedestrian and railway, they can also transport pipelines and power distribution lines over an obstacle that can be a river, ravine, or any other unevenness of the land (Lozano, 2023). The technique used was bibliometric analysis obtained from scientific and indexed databases (Noriega et al., 2023).

Procedure

In the research, the objective of the study was established, and then an exhaustive search for information was carried out that would serve as theoretical support to carry out the analysis;

Likewise, the heuristic method, the analysis method, the synthesis method and the statistical method were applied (Tamayo, 2012). Data for bibliometric analysis were downloaded in CSV format and processed with Microsoft Excel (version 2019). These sources included the journal title, publication date, author details (name, affiliation, author ID), article title, keywords, abstract, and number of citations.

Data Analysis Method

In bibliometric analysis research, it is the quantitative study of activity in scientific, technological and technical research (Romaní et al., 2011). The analysis of the scientific publications constitute a fundamental link within the research process and therefore, it has become a tool that allows qualifying the quality of the knowledge- generating process and the impact of this process on the environment (Rueda- Clausen et al., 2005). In this way, the Bibliometrics provides information on the results of the research process, the volume, the evolution, the visibility and structure; and scientific activity can be assessed, and the impact of both the research and the sources (Escorcia & Poutou, 2009).

Ethical Aspects

The purpose of the research is to contribute to the knowledge and scientific development of quality management systems in the development of modular bridges; This being a topic of interest for communities and being able to generate progress for their inhabitants. In that sense, Ojeda et al. (2007) points out that ethics is a primary factor for the development of society, it establishes behavioral guidelines that regulate human action and scientific research. Likewise, Rosales (2021) mentions that ethics is the fundamental pillar of every human being since this allows us to reflect with integrity and coherence between our thoughts and actions.

RESULTS AND DISCUSSION

The descriptive results are presented in relation to the evolution of scientific production in terms of articles and citations, distribution of scientific production by countries, institutions and most productive authors and most cited articles. Table 2 presents a summary of the data used to develop this bibliometric study.

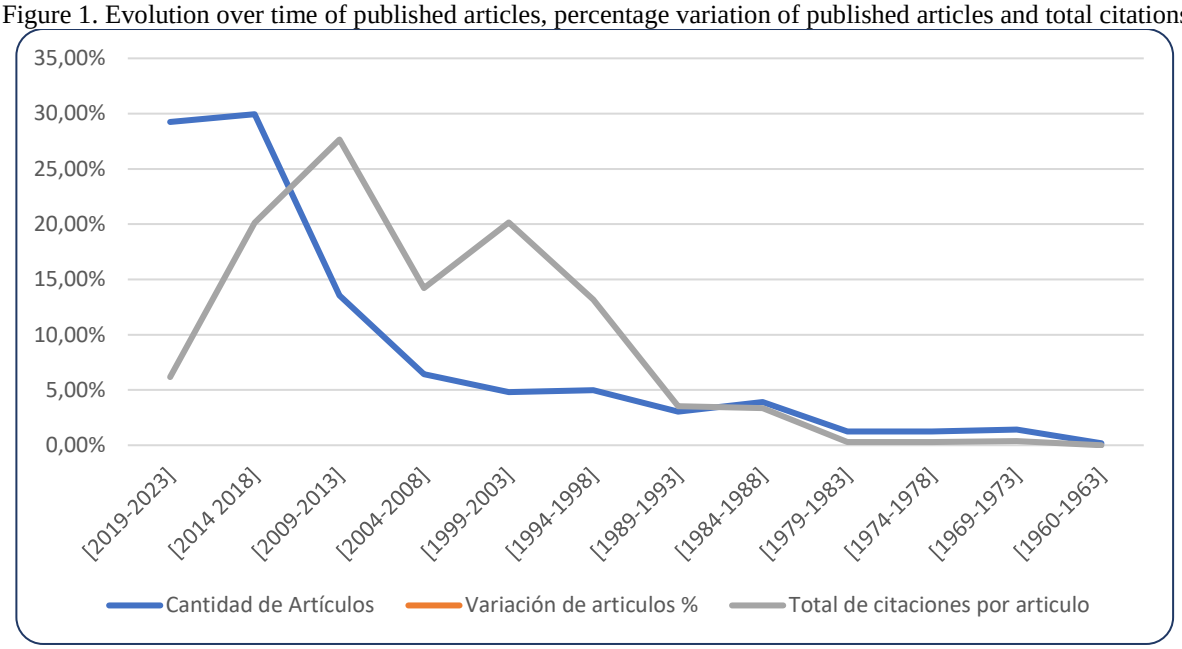
Table 2. Data Summary

Data	Quality management research in the development of bridges
Number of items	561
Number of magazines	267
Number of authors	267

Number of countries	674
Number of citations	8060
Citations/authors	30.19
Citations/articles	14.37

Source: Prepared by the author (2023)

Figure 1. Evolution over time of published articles, percentage variation of published articles and total citations



Source: Prepared by the author (2023)

Table 2 and Figure 1 show that quality management in bridge development has been a topic of great interest since the early 2000s and that the number of published articles has increased steadily since 2014. In the first 60 years of research on quality management in the development of bridges, only 18% of the recovered articles were published, while in the last decade (2014-2023), almost 58% of them were published. Likewise, it shows that the percentage variation of articles published per period, the number of citations per article and the number of articles published in the Scopus database, which, as can be seen, have increased considerably in recent years. These results, which coincide with those of previous research, indicate that, in the first years examined in this work, there was little scientific production on the topic.

Table 3. Significant characteristics of scientific production

Periods	Number of Items	Number of Authors	Authors/Articles	Number of countries	Number of magazines	Total citations in articles	Total citations per article
[2019-2023]	164	56	0.34	213	120	1013	6.18
[2014 2018]	168	121	0.72	217	80	3379	20.11
[2009-2013]	76	27	0.36	89	13	2102	27.66
[2004-2008]	36	11	0.31	42	4	512	14.22
[1999-2003]	27	35	1.30	29	0	544	20.15
[1994-1998]	28	2	0.07	28	0	369	13.18
[1989-1993]	17	4	0.24	15	0	60	3.53
[1984-1988]	22	10	0.45	19	0	74	3.36
[1979-1983]	7	0	0.00	7	0	2	0.29
[1974-1978]	7	0	0.00	8	0	2	0.29
[1969-1973]	8	1	0.13	6	0	3	0.38
[1964-1968]	0	0	-	0	0	0	-
[1960-1963]	1	0	0.00	1	0	0	0.00

Source: Prepared by the author (2023)

Table 3 details essential information about the published studies, such as the average number of citations per period, the number of authors per period, the average number of authors per article, the number of journals that published articles per period. and the number of countries that published articles per period. From 2014 to 2018, the largest number of works related to quality management in bridges was published, that is, 168 articles, which demonstrates the great interest of researchers in addressing this topic. Although 168 articles were published between 2014 and 2018, these were the most cited, with a total of 3,379 citations, followed by articles published between 2009 and 2013 and between 2019 and 2023, with 2,102 and 1,013 citations, respectively. The number of scientific journals that publish topics related to quality management in bridges increased significantly since 2009. In this sense, Casarin & Irastorza (2014) point out that, the summons allows _ update of textual fragments, and can be analyzed, on the one hand, considered as an indispensable requirement of every scientific text, which cannot do without a scholarly apparatus or, at least, a minimum set of references. Along these lines, González et al. (2015) notes that, the citations They play a crucial role in the discourse of science and, particularly, in the genre of the scientific article; through the summons they conform shared bodies of disciplinary literature, extensive networks of scientific communication.

Table 4. Scientific journals with a high range of technological productivity

Magazine	Articles	Country	Citations	1st author	Last Author	Citations/Year	H-Index
National Natural Science Foundation of China.	34	China	416	2012	2023	32.00	12
National Key Research and Development Program of China.	6	China	42	2019	2022	8.40	2
National Science Foundation.	5	Canadá	170	2013	2019	21.25	5
China Postdoctoral Science Foundation.	4	China	10	2015	2022	1.11	2
U.S. Department of Transportation.	4	Canadá	36	2016	2021	5.14	4
Bundesministerium für Bildung und Forschung.	3	Germany	41	2006	2020	2.56	2
Conselho Nacional de Desenvolvimento Científico e Tecnológico.	3	Brazil	40	2016	2021	5.71	2
Department of Science and Technology, Ministry of Science and Technology, India.	3	India	1	2021	2022	0.33	1
Fundamental Research Funds for the Central Universities.	3	China	67	2018	2021	13.40	3
National Research Foundation of Korea.	3	Korea	77	2015	2019	12.83	3

Source: Prepared by the author (2023)

Table 4 shows the 10 most productive journals in this field of research in the design and development of modular bridges. These journals published 12.12% (68 of 561) of the total articles included in this study, which shows that works on this research topic are dispersed and distributed in a large number of different publications. It is worth mentioning that the first journal in this ranking published 34 articles that generated a total of 416 citations, while the second journal obtained a total of 42 citations for 6 published studies. Consequently, Rojas et al. (2021) points out that, in this context, universities constitute the space to promote research, technological development and innovation capabilities based on the social benefit; It is necessary to delve deeper into the investigative process that is developed in their scenarios, where they are integrated the theory and practice based on scientific policies.

Table 5. Most productive countries in research on quality management in bridge development

Country	Number of Items	Number of Citations	Citation /article	1st article	Last article	Citation / Average citation	H-Index
China	147	1587	10.80	2001	2023	69.00	20
Estados Unidos	110	2228	20.25	1960	2023	34.81	23
India	42	350	8.33	1995	2022	12.50	9
Reino Unido	34	833	24.50	1993	2023	26.87	16
Alemania	28	235	8.39	1996	2023	8.39	9
Canadá	21	678	32.29	2003	2022	33.90	10
Corea del Sur	16	259	16.19	2006	2022	15.24	7
Australia	14	367	26.21	2012	2022	33.36	7

Italia	14	368	26.29	1984	2022	9.44	10
España	11	163	14.82	2007	2020	11.64	6

Source: Prepared by the author (2023)

However, as shown in Table 5, the majority of articles, 333 of 561, were published in only four countries. It is worth mentioning that an article can represent more than one country because the countries of publication are indicated by the researchers' affiliation institutions. China leads the list of countries with 147 publications; In second place, but far behind, is the United Kingdom with 110 articles. India ranks third with 42 research articles, while the United Kingdom ranks fourth with 34 published articles. Another characteristic detailed in Table 5 is the total number of citations. The United States is again in first place with 2,228 citations, China is in second place with 1,587 citations, while India is in third place with 350 citations. This indicator shows that research from these countries has a very significant impact and great prestige. Other countries, such as Spain and Germany, have fewer citations, 163 and 235, respectively. Regarding the h-index, the United States once again occupies first place with 23, China occupies second place with an h-index of 260, while the United Kingdom occupies third place with an h-index of 16. Finally, it is relevant to mention that the United States and the United Kingdom are the countries that have the longest history of research on quality management, continuing steadily until 2023, which could encourage growth of interest in this topic. In this regard, Lozano (2023) points out that, the Implementations of permanent modular bridge infrastructure projects are replacing old ones concrete bridges, either due to their versatility to adapt to any application or the speed of installation. On an international level, modular bridges are highly regarded, for example Acrow (2022) details the presence of this type of bridges in more than 80 countries around of the world, covering Africa, Asia, America, Europe and the Middle East, taking into consideration the technical and structural aspects.

Table 6. Most productive authors in research on quality management in bridge development

Author	Published articles	Citations	Citations/Articles	1st. Published Article	Last Article Published	Citation/Average citation	Country
Singh B.	7	137	19.57	2012	2022	12.45	India
Zhang J.	4	100	25.00	2016	2021	16.67	Estados unidos
Anon	3	5	1.67	1986	1996	0.45	Reino unido
Chen Y	3	28	9.33	2017	2017	28.00	China
Jacobina	3	15	5.00	2018	2022	3.00	Brasil
Li Y	3	142	47.33	2014	2016	47.33	China
Miki C.	3	15	5.00	2007	2010	3.75	Japón
Acuña P.	2	111	55.50	2007	2018	9.25	Chile
Al-Haddad K.	2	403	201.50	2010	2018	44.78	Canadá

Alampalli S.	2	4	2.00	2021	2023	1.33	Estados unidos

Source: Prepared by the author (2023)

Table 6 shows the 10 most productive authors on the topic of quality management in bridge development. These authors represent five universities, eight countries and three regions, among which Asia and Europe stand out, although there are also authors from North and South America. The author with the most publications is Singh B. with 7 articles, followed by Zhang J. with 4. Although Al-Haddad K. has only 2 published articles, he is the author with the highest number of citations, 403, which gives him a average number of citations per article of 201.50. The second author with the highest number of citations is Li Y. with 142, with 47.33 citations per article. Singh B. is in third place, with 137 citations and an average number of citations per article of 20,12.

Table 7. Most productive institutions in research on quality management in the development of modular bridges

Institution	Number of Items	Number of Citations	Citations/Articles	1st Article	Last Article	Citations / Average years	H-Index
Hunan University	12	240	20.00	2009	2022	17.14	6
Southeast University	8	115	14.38	2012	2022	10.45	5
Indian Institute of Technology Delhi	8	161	20.13	2012	2022	14.64	5
Purdue University	6	53	8.83	2000	2017	2.94	5
Fuzhou University	6	46	7.67	2017	2023	6.57	4
Tianjin University	6	25	4.17	2001	2022	1.14	2
Nanjing University of Aeronautics and Astronautics	6	124	20.67	2008	2022	8.27	4
Chinese Ministry of Education	5	61	12.20	2019	2021	20.33	3
University of Florida	5	615	123.00	2011	2021	55.91	4
Xi'an Jiaotong University	5	99	19.80	2012	2022	9.00	3

Source: Prepared by the author (2023)

Table 7 shows the main characteristics of the 10 most productive institutions in quality management research in bridge development. from 1954 to 2023. These institutions are located in seven countries. Spain has four institutions, the United Kingdom has two, while China, South Africa, the United States and Greece have one institution. Of this ranking, the first four institutions are Zhejiang Normal University, with 19 articles, followed by the University of South Africa and the University of Kent with 10 publications, while the University of Bristol has eight articles published. Regarding the number of citations per article, it can be seen that, although the University of Florida has five publications, it is the institution with the most

citations, 615. In second place is the University of Hunan with twelve published articles and 240 citations.

DISCUSSION

The objective of this work was, through a bibliometric analysis, to reflect the current state of the study of quality management in bridges and its research trends and to establish new future lines of research. The review covers a large number of articles, 561 in total, published in the period between 1960 and 2023, and retrieved using the Scopus database. To carry out the analysis, the main agents that contribute to the field of study were identified: Authors, institutions, journals and the most relevant thematic areas in which the articles are classified. The following conclusions can be drawn.

Firstly, since the first published article related to quality management in bridge development, the number of scientific publications has been increasing considerably over the years. 72.73% of the studies examined were published since 2009, indicating an important development of this line of research in recent years. This productive impulse may be related to the emergence of new techniques to predict quality management in the development of bridges and specific topics in industrial sectors. It is precisely in the period 2019-2023 when more than 39% of the total production on quality management in the development of bridges, with a total of 164 articles.

In second place, the most productive journals on quality management research in bridge development were National Natural Science Foundation of China, National Key Research and Development program of China and National Science Foundation, with 34, 6 and 5 articles published, respectively.

Thirdly, Singh B. is the most prolific researcher, with 7 published articles and the highest publication rate measured by the h-index (4). In second place is Zhang J., with 4 published articles and an h-index of 3. The authors work at the Delhi Institute of Technology and the University of Florida and have 137 and 100 citations, respectively. Therefore, his work has set the trend in this line of research in the last 10 years. Although Al-Haddad K. has 2 published works, he is one of the authors with the highest number of citations (403) and the highest average number of citations per article (201.50). Finally, this research provides experienced researchers with an overview of the evolution of this area of study and the possibility of generating future efforts to investigate underexplored environments.

The present study has some limitations, which could be the basis for future research. Likewise, future studies could expand these results using other databases and Scopus and applying other quantitative or qualitative instruments. Other types of documents, in addition to articles, such as books, conference proceedings; They could also be incorporated into new studies.

CONCLUSION

This work has shown how quality management in the development of bridges can be contemplated from very different points of view through the use of bibliometric tools such as those implemented here, which allow a level of detail that from any other perspective would be little. likely. be achieved. It has been particularly significant to note that this global phenomenon has had special significance in those nations that have recently incorporated new scientific findings regarding quality management in the development of modular bridges. This work contributes to the theoretical development of research on quality management in the development of modular bridges due to their efficiency and structural resistance, helps researchers identify the main research aspects and, above all, future lines of research.

RECOMMENDATION

It is recommended that through this study scientific and technical considerations be taken in the process of implementing quality management systems in the construction of modular bridges such as soil mechanics, topographic studies, the geology of the area, climatic factors. and socioeconomic development of the population centers of the high Andean and Amazon region.

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