International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 11 Issue: 02 | Feb 2024 www.irjet.net p-ISSN: 2395-0072

Analysis of Composite Stub Columns: A Bibliometric Review

Munaf Mohamed Salem Hasson [1], Mohammed Saleh Nusari [2]

[1] *Faculty of Engineering, Department of Civil Engineering, Lincoln University College, Petaling Jaya 47301, Malaysia*
[2] *Department of civil engineering, Faculty of Engineering, University of Aden, Aden, Yemen*

Abstract - *This research conducts an in-depth bibliometric analysis of 689 papers focusing on the use of concrete-filled steel tubes (CFST) in composite structures. Utilizing Web of Science and Scopus databases, the study employs Bibliometrix within the R software for systematic data gathering and analysis. Citation analysis identifies influential publications, authors, and institutions, evaluating scholarly impact and trends in CFST research from 2019 to 2023. The study identifies four research clusters, including Digital Transformation and CFST Applications, through bibliographic coupling. Findings reveal a fluctuating growth trend in cited publications, with a notable peak in 2022, emphasizing efforts to enhance CFST performance. Eminent contributors such as Dr. CHEN M, Prof. LIU Y, and Prof. ZHANG J are highlighted, and science mapping illustrates keyword evolution and collaboration networks, providing a holistic perspective on the CFST research landscape*.

Key Words: **Web of Science, Scopus, Bibliometric analysis, RStudio, Compositestructure,and Structural Behaviour.**

1.INTRODUCTION

Concrete-filled steel tubes (CFST) stand as prominent components in structural engineering, acclaimed for their heightened load-bearing capacity, durability, remarkable fire resistance, and seismic stability, as attested by[1]. The amalgamation of steel tubes and concrete cores not only mitigates inherent concrete brittleness but also augments damping resistance, as elucidated by [2]. CFSTs find extensive application as load-bearing columns in tall structures, showcasing exceptional resilience to compressive stresses and ductility. The nuanced interaction between steel tubes and concrete, especially during post-buckling phases, necessitates a departure from presumptions of homogenous cross-sections, prompting a more accurate conceptualization of CFST as composite entities rather than uniform structures, an assertion supported by [3]. Local buckling intricacies, influenced by concrete constraints, significantly impact CFST behavior under compression, revealing a complex interplay between buckling strain, residual strength, and steel tube deformation properties [4].Disparities arising from the differential Poisson's ratio between steel tubes and concrete within the elastic range lead to gradual compressive stress growth, delaying the emergence of confining stress in CFST steel tubes, particularly evident in thin-walled and high-strength concrete configurations[5]. Many studies showed that the stiffness of CFST columns made of high-strength concrete rapidly decreased during the initial post-buckling period[6]. The limitations of modeling CFST concrete cores using the constrained mechanical model of steel tube confined concrete stub columns (STCCs) are underscored. Eurocode 4's composite element theory, explored by scholars like[7], emerges as a pivotal framework, demanding the amalgamation of individual axial capacities of steel tubes and concrete cores to ascertain the axial load-bearing capability of CFST columns. This study addresses the qualitative and subjective nature of manual-based reviews by employing bibliometric and qualitative analyses, ensuring an objective and accurate examination of research articles in the CFST field from 2019 to 2023. The ensuing sections delve into the intricacies of bibliometric methodologies, offering a comprehensive exploration of academic contributions, discernible research trajectories, and prevailing trends in the specialized domain of stiffened CFST stud columns, fostering a nuanced understanding of information dynamics, research impacts, and broader influences shaping the field.

2. BIBLIOMETRIC ANALYSIS METHOD

The bibliometric analysis method under consideration involves a comprehensive scrutiny and interpretation of data acquired through bibliometric techniques, surpassing mere numerical analysis to unveil profound insights into underlying patterns, relationships, and trends within the research landscape. In addition to numerical assessments, qualitative analysis is applied, wherein researchers meticulously examine and interpret qualitative facets of bibliometric data, including publication content, citation context, and emergent themes and concepts in the literature. This qualitative analysis employs research methods such as content analysis, thematic analysis, and discourse analysis to reveal latent meanings and nuances in the data. Conducting a qualitative analysis of bibliometric data allows researchers to gain insights into research topics, theoretical frameworks, methodological approaches, and conceptual developments within a specific field. It facilitates the identification of emerging research trends, exploration of interconnections between different studies, and comprehension of the intellectual structure of a research domain. Moreover, qualitative analysis of bibliometric methods aids in identifying research gaps, challenges, and opportunities, providing a nuanced understanding of the research landscape and paving the way for the identification of new

research directions and potential areas for collaboration.This method is specifically applied to assess the behavior and design of concrete-filled steel tube (CFST) stub columns under axial compression, employing bibliometric techniques for quantitative analysis of publications, citation patterns, and research trends. Recent studies in structural engineering, exemplified by[8]and[9]have utilized bibliometric methods to investigate various facets of the field. Ding et al.'s analysis highlights key research clusters, subject categories, and knowledge structures related to concrete-filled steel tube structures, providing a comprehensive overview of the field. Similarly,[9]conducted a bibliometric analysis to assess the current research status in structural engineering, utilizing co-word analysis and co-cited analysis for an in-depth examination of the research dataset. Co-word analysis enabled the investigation of terminology usage and word co-occurrence patterns, while co-cited analysis aimed to identify frequently cited authors, articles, and journals. Additional analytical approaches, such as cluster analysis and timeline analysis, were employed to uncover significant clusters of related research and temporal patterns or shifts in scholarly discourse. These supplementary analyses served to identify trends and spikes in publication activity, offering a more comprehensive understanding of the research landscape.

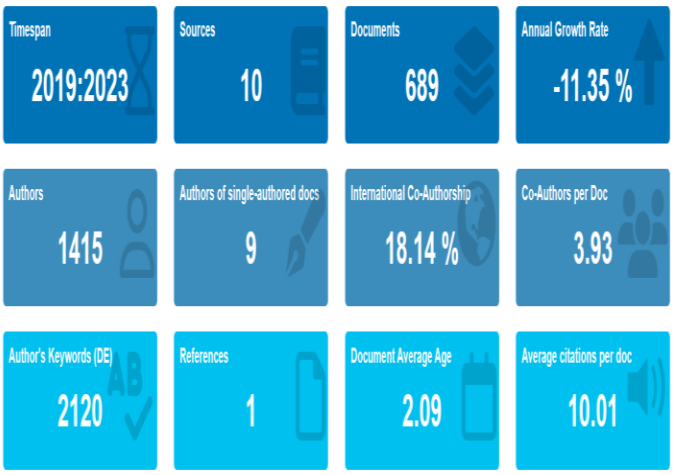

Figure 1. The Methodology of Bibliometric Analysis.

3. BIBLIOMETRIC PERFORMANCE ANALYSIS

Bibliometric performance analysis provides insights into the scholarly impact and research trends in the field of concrete-filled steel tube (CFST) stub columns under axial loading. Recent studies have employed bibliometric methods to assess publication productivity, citation impact, and collaboration patterns within this domain. For example, [10] conducted a comprehensive bibliometric analysis of CFST structures, while [11] focused on steel-concrete composite structures, including CFST columns. Such analyses help identify influential publications, leading researchers, and emerging research topics. By examining bibliometric indicators and utilizing mapping techniques, researchers can gain a deeper understanding of the research landscape and address knowledge gaps in CFST stub columns under axial loading.

3.1 The Configuration of Scholarly Publications and Citations

A critical aspect of assessing research trends and recognizing influential contributions lies in understanding the structure of publications and citations. Recent inquiries into this domain, such as the bibliometric analysis conducted by [12]on Concrete-Filled Steel Tube (CFST) structures, have illuminated publication productivity and citation impact, identifying key contributors at the author, institutional, and national levels. Similarly, [13]delved into citation patterns of CFST stub columns, discerning highly cited articles and influential research groups. By scrutinizing publication and citation structures, researchers can glean insights into the intellectual framework of the field, emerging research trends, and collaborative endeavors. This analysis aids in recognizing seminal works, influential authors, and research clusters, thereby fostering knowledge dissemination and advancing understanding in CFST stub columns under axial loading. Figure 2 visually represents the distribution of publications and citations up to April 2023, offering a graphical portrayal of their evolution over time. To enhance the overview's comprehensiveness, various citation thresholds have been incorporated, enabling a detailed analysis of citation patterns within the specified timeframe (2019 to 2023). The records reveal a fluctuating growth trend in cited publications, with a notable peak observed in 2022. This surge is attributed to ongoing efforts focused on improving the performance of CFSTs through diverse steel stiffening schemes, aimed at enhancing bond behavior and concrete confinement strength provided by the steel tube.

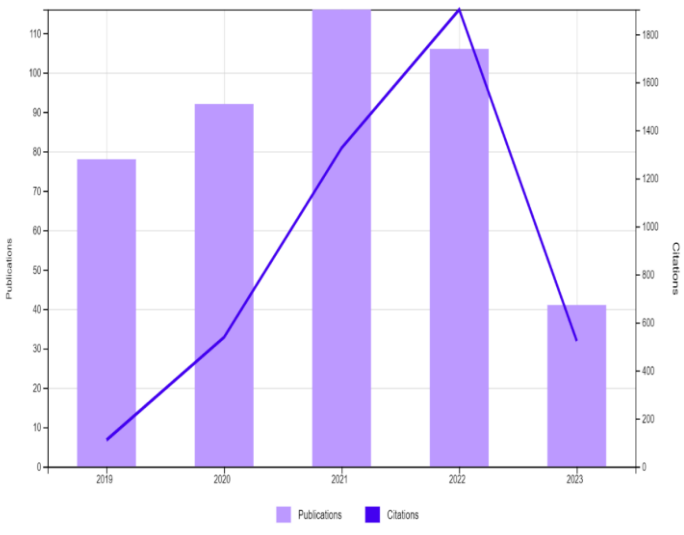

Figure 2. Annual publication and citation structure.

Table 1. Most cited papers

R	Title	Paper/Authors/year	DIO	Total	Total	Normal
1	A path-dependent stress-strain model for concrete-filled-steel-tube column Copy	LAI MH, 2020, ENG STRUCT	10.1016/j.engstruct.2020.110312	121	30.25	1.91
2	Experimental and numerical investigation into the behaviour of face-to-face built-up cold-formed steel channel sections under compression	ROY K, 2019, THIN-WALLED STRUCT	10.1016/j.tws.2018.09.045	106	21.20	1.30
3	Static behavior of large stud shear connectors in steel-UHPC composite structures	WANG JQ, 2019,	10.1016/j.engstruct.2018.07.058	97	19.40	1.19
4	Experimental and numerical investigations on the axial capacity of cold-formed steel built-up box sections	ROY K, 2019, J CONSTR STEEL RES	10.1016/j.jcsr.2019.05.038	96	19.20	1.17
5	Uni-axial behaviour of externally confined UHSCFST columns	LAI MH, 2019, THIN-WALLED STRUCT	10.1016/j.tws.2019.04.047	80	16.00	0.98
6	Numerical study on the axial compressive behavior of builtup CFT columns considering different welding lines	SHARIATI M, 2020, STEEL COMPOS STRUCT	10.12989/scs.2020.34.3.377	79	19.75	1.25
7	Stress-strain model of an FRP-confined concrete-filled steel tube under axial compression	ZHANG Y, 2019, THIN-WALLED STRUCT	10.1016/j.tws.2019.05.009	73	14.60	0.89
8	Seismic design and sub-assemblage tests of buckling-restrained braced RC frames with	BAI JL, 2021,	10.1016/j.engstruct.2021.112018	68	22.67	1.55

	shear connector or gusset connections					
9	Experimental study on axial compressive behavior of welded built-up CFT stub columns made by cold-formed sections with different welding lines	NAGHIPOUR M, 2020, STEEL COMPOS STRUCT	10.12989/scs.2020.34.3.347	67	16.75	1.06
10	Confinement effectiveness of circular concrete-filled steel tubular columns under axial compression	WEI Y, 2019, J CONSTR STEEL RES	10.1016/j.jcsr.2019.03.012	62	12.40	0.76
11	Monotonic axial compressive behaviour and confinement mechanism of square CFRP-steel tube confined concrete	WANG Y, 2020, ENG STRUCT	10.1016/j.engstruct.2020.110802	59	14.75	0.93
12	Advances in the Direct Strength Method	SCHAFER BW, 2019, THIN-WALLED STRUCT	10.1016/j.tws.2019.03.001	58	11.60	0.71
	of cold-formed steel design					
13	Deep learning-based procedure for structural design of cold-formed steel channel sections with edge-stiffened and un-stiffened holes under axial compression	FANG Z, 2021, THIN-WALLED STRUCT	10.1016/j.tws.2021.108076	53	17.67	1.20
14	Experimental investigation on cold-formed steel stiffened lipped channel columns undergoing local-distortional interaction	CHEN M-T, 2020, THIN-WALLED STRUCT	10.1016/j.tws.2020.106682	48	12.00	0.76
15	Simulation of screw connected built-up cold-formed steel back-to-back lipped channels under axial compression	KECHIDI S, 2020, ENG STRUCT	10.1016/j.engstruct.2019.110109	46	11.50	0.73
16	Parametric study	CHEN B, 2020, J	10.1016/j.jcsr.2020.106161	45	11.25	0.7

	and simplified design equations for cold-formed steel channels with edge-stiffened holes under axial compression	CONSTR STEEL RES				1
17	Analysis of uniaxially loaded short round-ended concrete-filled steel tubular beam-columns	PATEL VI, 2020, ENG STRUCT	10.1016/j.engstruct.2019.110098	42	10.50	0.66
18	Experimental investigation on cold-formed steel lipped channel beams affected by local-distortional interaction under non-uniform bending	CHEN M-T, 2021, THIN-WALLED STRUCT	10.1016/j.tws.2021.107494	35	11.67	0.80
19	Design of cold-formed steel built-up columns subjected to local-global interactive buckling using direct strength method	SELVARAJ S, 2021, THIN-WALLED STRUCT	10.1016/j.tws.2020.107305	33	11.00	0.75
20	Uni-axial behaviour of expansive CFST and DSCFST stub columns	HO JCM, 2021, ENG STRUCT	10.1016/j.engstruct.2021.112193	31	10.33	0.70
21	Design of concrete-filled cold-formed steel elliptical stub columns	YI S, 2023, ENG STRUCT	10.1016/j.engstruct.2022.115269	12	12.00	1.00

3.2.PROMINENT AUTHORS, INSTITUTIONS, AND COUNTRIES/REGIONS

The identification of leading contributors in concrete-filled steel tube (CFST) stub columns, particularly in the context of axial loading, yields valuable insights into the research landscape. Recent studies, exemplified by [14]and[9],conducted comprehensive bibliometric analyses to discern influential authors, institutions, and countries. Hossain et al. focused on leading authors, employing publication productivity and citation impact as criteria, highlighting the significant contributions of influential researchers. Similarly,[9],concentrated on institutions and countries, employing quantitative analysis of publication data. Noteworthy among the highly productive authors are Dr. CHEN M, Prof. LIU Y, Prof. ZHANG J, and Dr. WANG J. Dr. CHEN M's substantial contribution includes 14 scholarly papers spanning CFST and additive manufacturing applications, while Prof. WANG Y has primarily investigated the behavior of normal-strength recycled aggregate concrete-filled steel tubes, documented in the work by[15].The comprehensive overview, presented in Table 1, integrates various bibliometric indicators, such as author WoS and Scopus, countries/regions, number of citations, and cites per paper ratio, ranked based on the number of publications and resolved ties by considering citation numbers.

Table2. Most productive authors.

Author	year	freq	Total Citation	Total Citation /Year
CHEN M	2019	3	173	34.600
CHEN Y	2019	6	112	22.400
LIU Y	2019	9	174	34.800
MAHENDRAN M	2019	2	53	10.600
WANG J	2019	5	176	35.200
WANG X	2019	3	33	6.600
WANG Y	2019	6	107	21.400
ZHANG J	2019	3	42	8.400
ZHOU X	2019	2	36	7.200
CHEN J	2020	3	73	18.250
CHEN M	2020	3	210	52.500
LIU Y	2020	8	97	24.250
WANG Y	2020	6	155	38.750
CHEN M	2021	2	35	11.667
LIU Y	2021	5	52	17.333
MAHENDRAN M	2021	8	78	26.000
WANG J	2021	4	25	8.333
WANG X	2021	5	63	21.000
WANG Y	2021	6	40	13.333
ZHANG J	2021	6	38	12.667
ZHOU X	2021	2	32	10.667

Prof. LIU Y and Prof. ZHANG J received awards for significant contributions to "circular concrete-filled steel tube stub columns" (2020-2022). Prof. WANG X and Dr. ZHOU X transitioned to publishing on steel concrete composite stub columns under axial compression.Table 2 provides an insightful analysis of affiliations' productivity in the journal, presenting Affiliations Production over Time and relevant indicators. Beijing University of Technology leads with 104 articles (2019-2023). Chongqing University and the School of Civil Engineering follow closely, with the latter, despite fewer articles, demonstrating noteworthy productivity within the journal.

Table 3. Most Affiliations' Production over Time

R	Affiliations'	Years	Articles
1	BEIJING UNIVERSITY OF TECHNOLOGY	(2019-2023)	104
6	CHONGQING UNIVERSITY	(2019-2023)	214
11	SCHOOL OF CIVIL ENGINEERING	(2019-2023)	125
16	TSINGHUA UNIVERSITY	(2019-2023)	118
21	WUHAN UNIVERSITY	(2019-2023)	137

Table 3 offers an overview of countries/regions' scholarly productivity. China dominates globally, surpassing Australia and the United States. Notably, China stands alone in publishing over 300 articles and accumulating 3000 citations. Tables 2 and 3 underscore China and Australia's substantial representation, affirming their high standing. The MCP indicator suggests strong collaborative inclinations among China, Australia, the United States, and Canada.

Table 4. Most productive countries/regions.

R	Country/Region	Articles	Total Citation	Average article citation	SCP	MCP	Freq	MCP Ratio
1	CHINA	327	3065	9.4	286	41	0.475	0.125
2	AUSTRALIA	60	750	12.5	45	15	0.087	0.250
3	USA	31	376	8.40	21	10	0.045	0.323
4	INDIA	28	259	8.30	26	2	0.041	0.071
5	IRAN	26	232	7.50	19	7	0.038	0.269
6	CANADA	24	134	5.60	15	9	0.035	0.375
7	UNITED KINGDOM	24	188	7.80	17	7	0.035	0.292
8	KOREA	21	101	4.80	18	3	0.030	0.143
9	JAPAN	15	94	6.30	14	1	0.022	0.067
10	ITALY	13	139	10.70	10	3	0.019	0.231
11	MALAYSIA	11	126	11.50	8	3	0.016	0.273
12	BRAZIL	10	104	10.40	7	3	0.015	0.300
13	PORTUGAL	10	190	19.00	9	1	0.015	0.100
14	NEW ZEALAND	9	376	41.80	6	3	0.013	0.333

15	SINGAPORE	7	83	11,90	7	0	0.010	0.000
16	SPAIN	7	60	8.60	5	2	0.010	0.286
17	TURKEY	6	36	6.00	5	1	0.009	0.167
18	EGYPT	5	9	1.80	5	0	0.007	0.000
19	GERMANY	5	38	7.60	4	1	0.007	0.200
20	HONG KONG	5	86	17.20	5	0	0.007	0.000
21	IRAQ	3	13	4.30	1	2	0.004	0.667
22	IRELAND	3	65	21.70	3	0	0.004	0.000
23	FRANCE	2	59	29.50	2	0	0.003	0.000
24	LUXEMBOURG	2	42	21.00	1	1	0.003	0.500
25	THAILAND	2	35	17.50	0	2	0.003	1.000

Abbreviations: SCP/SRP = Single Country Production/Single Region Production; MCP/MRP = Multiple Country Production/Multiple Region Production.

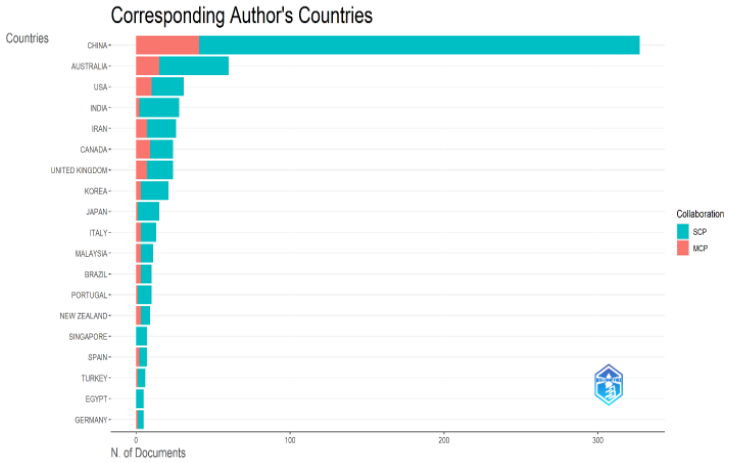

Figure 3.High-Performing Countries and Regions

4. SCIENCE MAPPING ANALYSIS

In this section, a science mapping approach was employed, incorporating key factors such as keywords, citation/co-citation analysis, and collaboration patterns. By utilizing these factors, a comprehensive analysis was conducted to reveal the interrelationships and trends within the scientific domain under investigation.

4.1. ANALYSIS OF KEYWORDS

The analysis commenced with an examination of prevalent author keywords in the journal, covering frequency, thematic mapping, growth patterns, and thematic evolution. Author keywords serve as concise representations of scholarly article themes, providing insights into authors' preferences and focal areas[9]. Figure 4. illustrates a word cloud of the 50 most frequent author keywords in papers on circular concrete-filled steel tube stub columns under axial compression. Notably, "tubular steel structures" is central, with "buckling" and "strength" following. Terms like "behavior," "concrete," "performance" (specifically in structural aspects), and "studs structural members" also hold significance. "Compressive strength" prominently emerges, especially in concrete-filled steel tube columns and high-performance concrete domains. Performance parameters like "local buckling," "static behavior," and "ductility" are frequently employed for investigating structural element behavior.

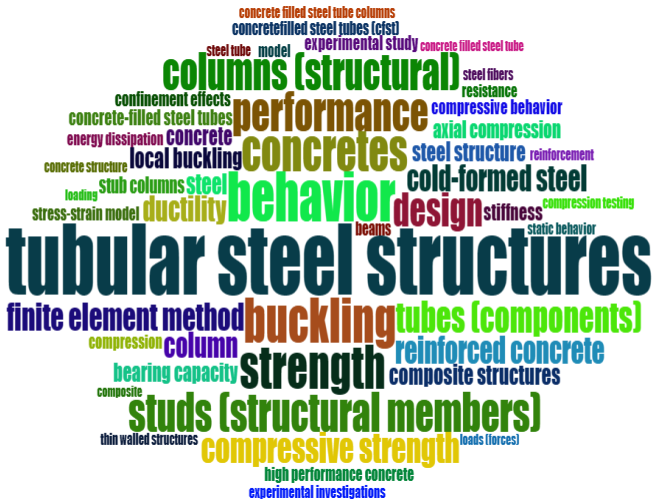

Figure4. Word cloud of keywords.

The paragraph introduces a thematic mapFigure 5. as a visual representation of the research landscape, utilizing author-defined keywords [16]. Employing two key dimensions, density and centrality, the thematic map elucidates internal connections and external associations among research themes. The upper-right quadrant, denoted as motor themes, emphasizes clusters pivotal to concrete-filled steel tube stub columns, with Cluster 1 incorporating keywords like "Tubular steel structures," "concretes," and "buckling," indicating high density and significance. The upper-left quadrant, termed niche themes, includes clusters with notable development but less crucial importance, such as "static behavior" and "shear connectors" in Cluster 1 and "behavior" and "performance" in Cluster 2. The lower-left quadrant, denoting emerging or declining themes, exhibits lower centrality and density with keywords like "strength" and "corrosion." The lower-right quadrant, representing basic themes, comprises fundamental but less developed clusters, including "design," "steel," and "concrete." This analysis offers insights into interrelationships and the significance of research themes within the concrete-filled steel tube stub columns domain.

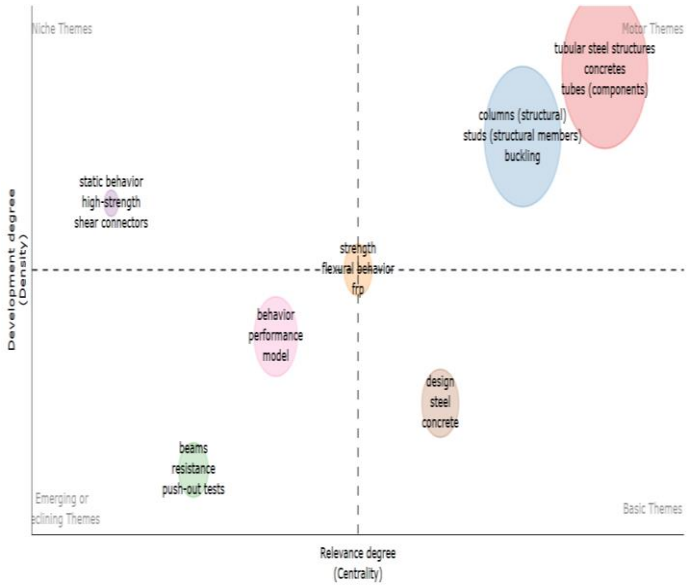

Figure 5. Thematic map of keywords.

This paragraph explores the annual growth patterns of the top 10 keywords, depicted in Figure 6. from 2019 to 2023. The visualization reveals a consistent annual increase in each keyword, reflecting the strengthening and development of concrete-filled steel tube stub columns under axial load. Notably, "performance," "buckling," and "strength" consistently rank among the top three, with "composite structures" showing a pronounced upward trajectory since 2021. "Circular concrete-filled steel tube stub columns under axial compression" has experienced rapid growth, becoming the sixth most common keyword in 2021. Despite having the fewest occurrences, "performance" has witnessed a significant increase post-2020, suggesting its anticipated continued relevance in future studies.

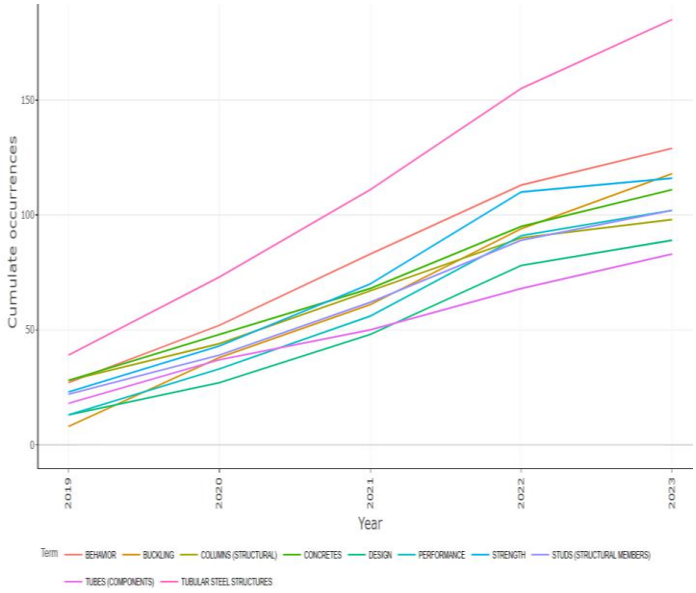

Figure 6. Growth of the top 10 keywords.

The paragraph delves into trending topics within concrete-filled steel tube stub columns under axial load. Figure 7. illustrates the frequency of keyword occurrences since 2019, with larger blue-filled circles indicating higher frequencies (ranging from 10 to 50). In 2019, "bolted connections," "micro-alloyed steel," and "concrete-filled steel tube" were prominent. In 2020, "experimental investigation," "concrete-filled steel tube," and "composite structures" gained attention. In 2021, "buckling," "behavior," and "tubular steel structures" were notable, continuing in 2022 with "concrete-filled steel tube (CFST)," "compression," and "local buckling." From 2022 to 2023, "ductile fracture," "short column," and "confined concrete" emerged. These topics are anticipated to sustain increased scholarly interest in concrete-filled steel tube stub columns.

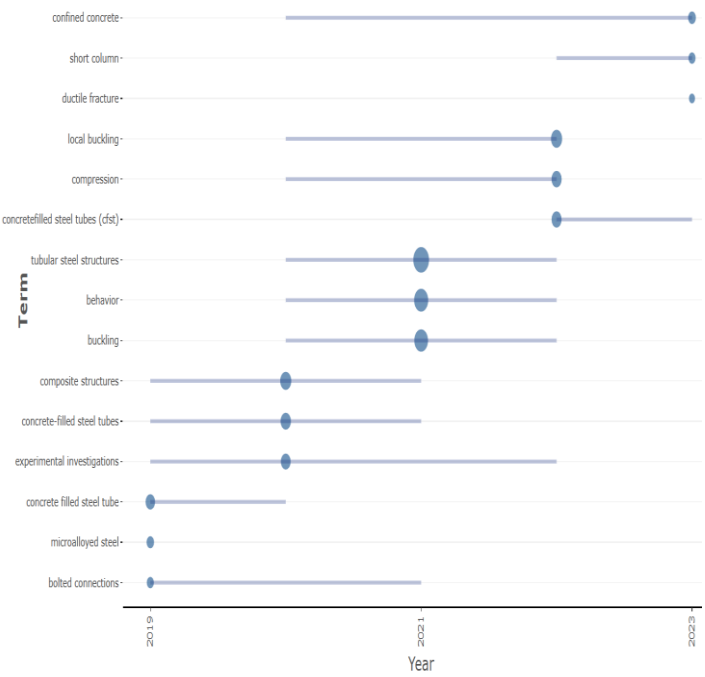

Figure 7. Latest trending topics.

The paragraph employs a Sankey diagram (Figure 8) to comprehensively analyze the thematic evolution of the journal over time[17].This visualization method reveals interconnections and developmental trajectories of various themes[18]. Each box in the diagram represents a distinct theme, with box size reflecting the frequency of occurrences. Thicker connecting lines indicate stronger thematic linkage. A holistic examination indicates increasing diversification of themes in circular concrete-filled steel tube stub columns, potentially due to scholars from diverse fields. "Cold-formed steel" showed sustained attention from 2019 to 2023, emerging as the most popular theme in 2022-2023. Conversely, indicators like "seismic behavior," "local buckling," and "axial compression" have recently gained prominence, indicating ongoing research efforts in these aspects.

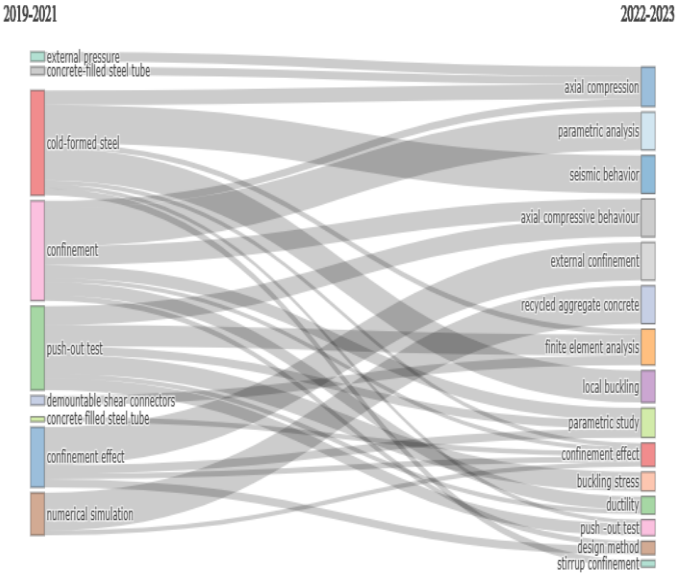

Figure 8. Thematic evolution.

4.2. ANALYSIS OF THREE-FIELDS PLOT

The three-field plot within the Bibliometrix tool is instrumental for a comprehensive understanding of bibliometric research, encapsulating multiple dimensions in a single figure[16]. Figure 9 effectively depicts three key aspects: the most active 15 countries/regions in the concrete-filled steel tube stub columns field on the left, corresponding keywords in the middle, and primary sources on the right. Scholars focus on "push-out test," "finite element analysis," "cold-formed steel," "confinement," and "local buckling," indicating current hot topics. Engineering structures, thin-walled structures, and construction and building materials prominently contribute to the field. China, Australia, and the USA lead in publications, covering diverse research areas, aligning with previous analyses.

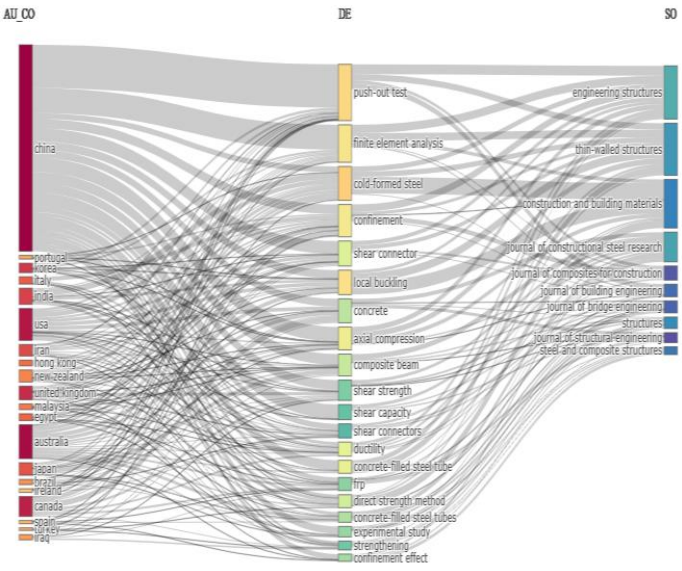

Figure 9. Three-fields plot.

4.3. ANALYSIS OF CITATIONS AND CO-CITATIONS

The historiography of concrete-filled steel tube stub columns, depicted in Figure 10a, aims to trace the historical development of this field through a chronological map based on significant citations. Each flow, color-coded for clarity, represents a direct citation, indicating the evolution of concepts over time. Nodes within the flows highlight core documents with high citations, considering both local and global citations. The largest citation stream in purple, stemming from [19]. research, provides insights into the ultimate bearing capacity of joints stiffened with external ring stiffeners. Notably, the most cited author, Qu, marked in purple, contributed novel methods in 2021 and 2022, enhancing column load capacity through tube stiffeners. The second-largest citation stream in red, beginning in 2019 and evolving in 2021, delves into the role of stiffeners and optimal design parameters for seismic performance improvement[20];[21] .

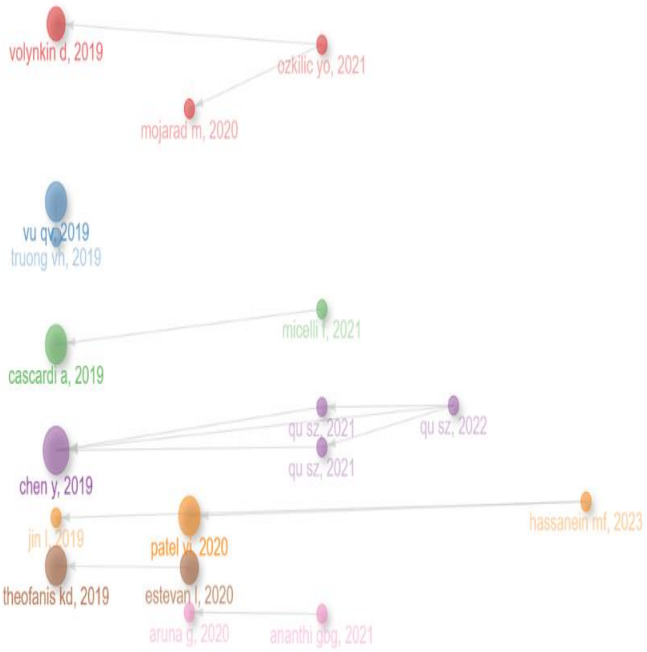

Figure 10 a. Historical direct citation network.

The analysis of co-citations among journals about publications on concrete-filled steel tube stub columns was conducted in this study. Co-citation refers to the occurrence when two documents from distinct journals receive citations from a common third document. Figure 10 b presents a visual representation of fifty journals involved in co-citations. The journals are depicted as colored circles, and the lines connecting them represent the co-linkages between journals. Furthermore, the size of each circle corresponds to the citation weight, indicating the relative significance of the journal in the co-citation network [22]. The resulting map

exhibits a clear division into three distinct clusters, distinguished by different colors. Notably, the largest circles in this network are associated with the fields of composite structures (represented in red), steel structures (represented in green), and advancedd structure engineering (represented in blue).

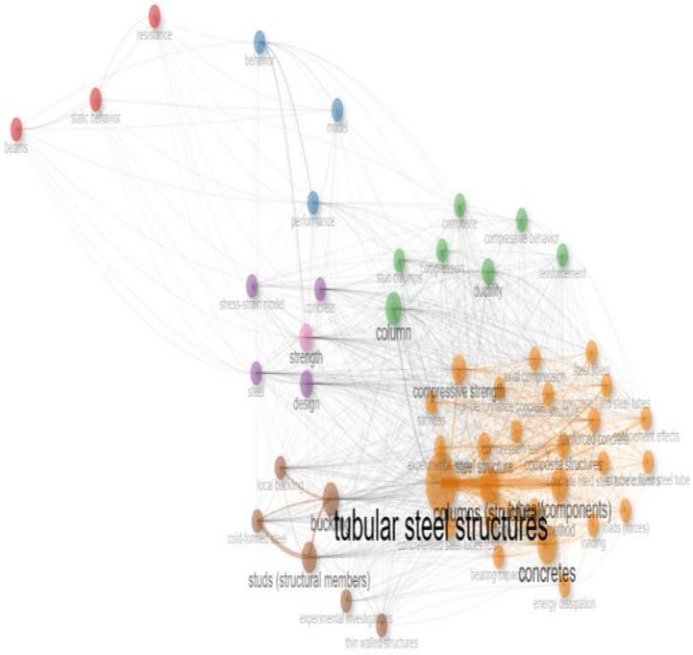

Figure 10 b. Co-citation network of journals.

4.4. ANALYSIS OF COLLABORATION

Figure 11 presents a collaboration network among institutions in the concrete-filled steel tube stub columns field. Institutions are depicted as colored circles, and their collaborations are represented by lines. The network is divided into seven clusters, each assigned a different color. Analysis reveals that institutions within the same cluster are predominantly from the same country or region. Notably, several Chinese institutions form a cluster, including Hunan University, Southeast University, Zhejiang University, and others. Australian institutions, such as The University of Sydney and La Trobe University, are also grouped. Noteworthy similarities in cumulative degree are observed between the School of Civil Engineering and Tsinghua University, as well as Chongqing Jiaotong University.

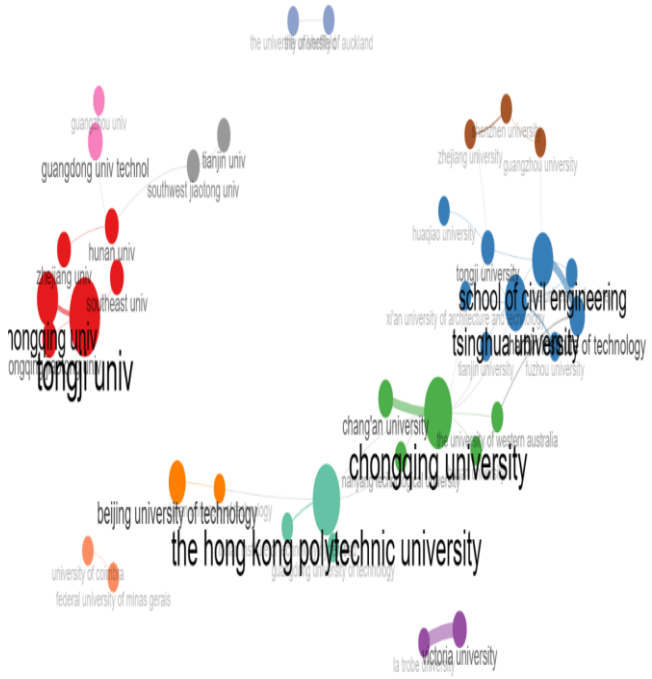

Figure 11. Collaboration network of institutions.

Concrete-filled steel tube stub columns demonstrate substantial international collaboration, facilitating global academic exchange and knowledge dissemination. The international collaboration network illuminates interrelationships among countries and regions in this specialized field. Figure 12 provides a geographic-level overview, with shading and line thickness representing the number and proportion of collaborations, respectively. Unsurprisingly, China emerges as the most active region, displaying robust collaboration with Australia. Figure 13 details countries/regions by collaboration size, denoted by circle size, and line thickness reflects collaboration closeness. China leads in collaborations, followed by the United Kingdom and the USA, highlighting their significant contributions to research output. Notably, China and Australia exhibit a strong connection, emphasizing their willingness to engage in collaborative research efforts within concrete-filled steel tube stub columns.

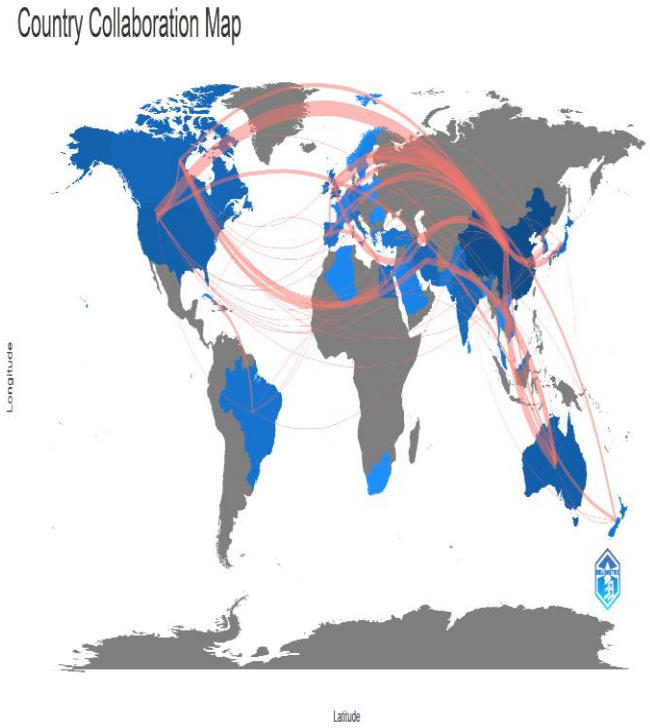

Figure 12. An overview of cooperation between countries/regions.

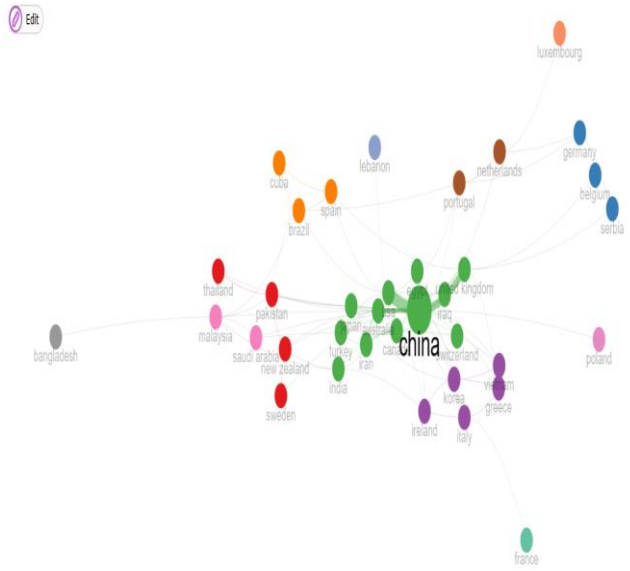

Figure 13. Collaboration network of countries/regions.

5. DISCUSSIONS AND CONCLUSIONS

This study conducts a comprehensive bibliometric analysis of journal publications on concrete-filled steel tubes from 2019 to 2023. Initially focusing on the journal's publishing and citation structure regarding performance analysis, the findings reveal the robust expansion of composite structures over time, with over 600 publications. The most-cited work, a path-dependent stress-strain model for concrete-filled steel tube columns authored in 2020, emphasizes the journal's global academic recognition. China emerges as the leader in research output, contributing 327 articles and receiving 3065 citations, surpassing Australia in the second position. Eminent contributors such as Professor CHEN M and Professor ZHANG J from China are highlighted.

The examination encompasses author-defined keywords, institutional analyses, citation patterns, co-citations, and collaborative research projects. Notable keywords include "Tubular steel structures" and "concretes," reflecting a preference for simulation techniques and structural behavior analysis. The collaboration network reveals seven clusters, indicating regional research collaboration, particularly among Chinese and Australian institutions.

Despite the study's in-depth analysis, certain weaknesses are acknowledged, including the need for a balance between quantity and quality in publications, as the increasing number of subfields requires careful consideration. The study's limitations, stemming from the Scopus and Web of Science databases, are recognized, with 23 documents being disregarded as duplicates. Future research should address these issues to enhance data quality and contribute to the advancement of knowledge in the field of concrete-filled steel tubes.

6. REFERENCES

[1] H. Dong, X. Liang, W. Cao, L. Zhao, and J. Zhang, "Cyclic behavior of circular CFST stub columns with different inner constructions," *J. Build. Eng.*, vol. 53, no. April, p. 104549, 2022, doi: 10.1016/j.jobe.2022.104549.

[2] X. Wang, J. Lai, J. Qiu, W. Xu, L. Wang, and Y. Luo, "Geohazards, reflection and challenges in Mountain tunnel construction of China: a data collection from 2002 to 2018," *Geomatics, Nat. Hazards Risk*, vol. 11, no. 1, pp. 766–784, 2020, doi: 10.1080/19475705.2020.1747554.

[3] C. Yang, Z. X. Yu, Y. P. Sun, L. Zhao, and H. Zhao, "Axial residual capacity of circular concrete-filled steel tube stub columns considering local buckling," *Adv. Steel Constr.*, vol. 14, no. 3, pp. 496–513, 2018, doi: 10.18057/IJASC.2018.14.3.11.

[4] C. Yang, H. Zhao, Y. Sun, and S. Zhao, "Compressive stress-strain model of cold-formed circular hollow section stub columns considering local buckling," *Thin-Walled Struct.*, vol. 120, no. March, pp. 495–505, 2017, doi: 10.1016/j.tws.2017.09.017.

[5] M. Su, Y. Cai, X. Chen, and B. Young, "Behaviour of concrete-filled cold-formed high strength steel circular stub columns," *Thin-Walled Struct.*, vol. 157, no. April, p. 107078, 2020, doi:

10.1016/j.tws.2020.107078.

[6] G. Du, Z. Liu, W. Jiao, H. Yuan, and T. Zhang, "Behavior of embedded steel profile ultra-high performance concrete-filled stainless steel tubular short columns under axial compression," *Structures*, vol. 54, no. May, pp. 183–197, 2023, doi: 10.1016/j.istruc.2023.05.006.

[7] Y. Wang, L. Yang, H. Yang, and C. Liu, "Behaviour of concrete-filled corrugated steel tubes under axial compression," *Eng. Struct.*, vol. 183, pp. 475–495, 2019, doi: https://doi.org/10.1016/j.engstruct.2018.12.093.

[8] Z. Ding, K. Zheng, and Y. Tan, "BIM research vs BIM practice: a bibliometric-qualitative analysis from China," *Eng. Constr. Archit. Manag.*, vol. 29, no. 9, pp. 3520–3546, 2022, doi: 10.1108/ECAM-01-2021-0071.

[9] Z. Xiao, Y. Qin, Z. Xu, J. Antucheviciene, and E. K. Zavadskas, "The Journal Buildings: A Bibliometric Analysis (2011–2021)," *Buildings*, vol. 12, no. 1, 2022, doi: 10.3390/buildings12010037.

[10] F. Alatshan, S. A. Osman, R. Hamid, and F. Mashiri, "Stiffened concrete-filled steel tubes: A systematic review," *Thin-Walled Struct.*, vol. 148, no. January, p. 106590, 2020, doi: 10.1016/j.tws.2019.106590.

[11] J. Thomas and T. N. Sandeep, "Capacity of short circular CFST columns with inner vertical plates welded intermittently," *J. Constr. Steel Res.*, vol. 165, p. 105840, 2020, doi: 10.1016/j.jcsr.2019.105840.

[12] Y. Zhang, M. Deng, R. Li, Z. Dong, and H. Sun, "Axial behavior of engineered cementitious composites confined by circular steel tubes," *Eng. Struct.*, vol. 224, no. August, p. 111216, 2020, doi: 10.1016/j.engstruct.2020.111216.

[13] J. X. Li, J. T. Wang, Q. Sun, Y. R. Wu, S. M. Zhou, and F. C. Wang, "Axial Compression Behavior of Circular Concrete-Filled High-Strength Thin-Walled Steel Tubular Columns with Out-of-Code D / t Ratios," *Adv. Mater. Sci. Eng.*, vol. 2021, 2021, doi: 10.1155/2021/9081566.

[14] M. U. Hossain, J. C. Liu, D. Xuan, S. T. Ng, H. Ye, and S. J. Abdulla, "Designing sustainable concrete mixes with potentially alternative binder systems: Multicriteria decision making process," *J. Build. Eng.*, vol. 45, no. September 2021, p. 103587, 2022, doi: 10.1016/j.jobe.2021.103587.

[15] J. Chen, Y. Wang, C. W. Roeder, and J. Ma, "Behavior of normal-strength recycled aggregate concrete filled steel tubes under combined loading," *Eng. Struct.*, vol. 130, pp. 23–40, 2017, doi: 10.1016/j.engstruct.2016.09.046.

[16] J. R. Mumu, T. Tahmid, and M. A. K. Azad, "Job satisfaction and intention to quit: A bibliometric review of work-family conflict and research agenda," *Appl. Nurs. Res.*, vol. 59, p. 151334, 2021, doi: 10.1016/j.apnr.2020.151334.

[17] M. Aria, M. Misuraca, and M. Spano, "Mapping the Evolution of Social Research and Data Science on 30 Years of Social Indicators Research," *Soc. Indic. Res.*, vol. 149, no. 3, pp. 803–831, 2020, doi: 10.1007/s11205-020-02281-3.

[18] Abhishek and M. Srivastava, "Mapping the influence of influencer marketing: a bibliometric analysis," *Mark. Intell. Plan.*, vol. 39, no. 7, pp. 979–1003, 2021, doi: 10.1108/MIP-03-2021-0085.

[19] Y. Chen *et al.*, "Ultimate bearing capacity of CHS X-joints stiffened with external ring stiffeners and gusset plates subjected to brace compression," *Eng. Struct.*, vol. 181, no. December 2018, pp. 76–88, 2019, doi: 10.1016/j.engstruct.2018.12.005.

[20] S. Qu, S. Wei, J. Yuan, and Q. Sun, "Tension and compression stiffness of ring stiffener in tube–gusset plate connections," *Thin-Walled Struct.*, vol. 166, no. June, p. 108067, 2021, doi: 10.1016/j.tws.2021.108067.

[21] S. Qu, Q. Li, Y. Wang, J. Yuan, and Q. Sun, "Failure pattern and load distribution mechanism of stiffeners in the tube–gusset plate connection: Testing, numerical modelling and theoretical analysis," *Structures*, vol. 36, no. October 2021, pp. 951–978, 2022, doi: 10.1016/j.istruc.2021.12.049.

[22] D. Guleria and G. Kaur, "Bibliometric analysis of ecopreneurship using VOSviewer and RStudio Bibliometrix, 1989–2019," *Libr. Hi Tech*, vol. 39, no. 4, pp. 1001–1024, 2021, doi: 10.1108/LHT-09-2020-0218.