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Global Research Trends on Rebar Coatings in Reinforced Concrete: Corrosion Resistance and Bond Behavior (2014–2024)

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ABSTRACT

Corrosion of reinforcing steel significantly undermines the durability and structural integrity of reinforced concrete (RC) systems, especially in aggressive environments. Protective rebar coatings have emerged as a practical and effective solution to enhance corrosion resistance and maintain steel-concrete bond strength. This paper presents a comprehensive bibliometric and systematic review of global research trends from 2014 to 2024 on rebar coatings in RC structures. The bibliometric analysis, conducted using Scopus data and VOS viewer, highlights prolific authors, institutions, collaboration networks, and key thematic areas. Simultaneously, the systematic review critically assesses the types of coatings used including epoxy, galvanized, stainless steel, and emerging nanocomposites, their mechanisms of action, and their influence on bond behavior. Results indicate a notable growth in research output, with China, the USA, and India leading global contributions. While coated rebars significantly improve corrosion resistance, their effect on bond performance varies with coating type and application method. The study identifies gaps in field validation and sustainability assessments and suggests future directions for interdisciplinary research, including AI-based modeling, life cycle analysis, and performance-based standards for coated reinforcement systems. These insights contribute to advancing durable, sustainable, and resilient infrastructure.

1. Introduction

Reinforced concrete (RC) is one of the most extensively used construction materials worldwide due to its high compressive strength, structural efficiency, and cost-effectiveness[1], [2]. However, the long-term durability and serviceability of RC structures are significantly influenced by the performance of embedded steel reinforcement, particularly under aggressive environmental conditions[3]. Among the most pressing durability concerns is the corrosion of reinforcing steel, which leads to the deterioration of structural integrity, reduction in bond strength between steel and concrete, and ultimately, premature failure of infrastructure[3]–[6].

Corrosion-induced damage in RC structures is especially prevalent in marine environments, regions with high humidity, and areas exposed to de-icing salts and industrial pollutants[7]–[9]. The ingress of chloride ions and carbonation are two primary mechanisms responsible for the DE passivation of the steel surface, initiating corrosion[10]–[12]. As steel corrodes, it expands and produces rust products that exert internal pressure on the surrounding concrete, leading to cracking, delamination, and spalling[4], [13]. Furthermore, corrosion significantly degrades the bond between steel and concrete a critical factor in the load transfer mechanism in RC structures[9], [13]–[19]. This degradation not only compromises structural safety but also results in escalating maintenance and rehabilitation costs[20]–[22].

To address this challenge, various protective strategies have been explored, including the application of coatings to reinforcing bars[23]–[25]. Coatings such as epoxy, galvanized zinc, stainless steel cladding, and advanced polymeric treatments serve to delay or prevent corrosion initiation and mitigate its propagation. Each coating type presents unique advantages and limitations in terms of corrosion resistance, mechanical interaction with concrete, cost, and field applicability. For instance, epoxy-coated reinforcement (ECR) is widely used due to its barrier properties, while hot-dip galvanizing provides sacrificial protection. More recent research also focuses on nano-coatings and hybrid materials with enhanced durability characteristics[26]–[28].

In addition to corrosion resistance, the bond behaviour of coated reinforcement has attracted significant attention. The coating can alter surface roughness, chemical composition, and interfacial behaviour, potentially affecting the bond strength and overall performance of the RC element[29]–[31]. While some studies report negligible or even improved bond strength due to coatings, others have noted a reduction in mechanical interlocking, slip resistance, and anchorage capacity. Therefore, understanding the dual impact of rebar coatings on corrosion resistance and bond behaviour is vital for ensuring structural reliability and service life extension[32], [33].

Over the past few decades, the academic and engineering communities have produced a substantial body of research on coated reinforcement and its performance in concrete. However, despite this growing interest, no comprehensive bibliometric analysis has yet been conducted to systematically map the scientific landscape, identify influential publications and researchers, trace thematic trends, and uncover emerging areas of interest.

This study aims to fill that gap by conducting a bibliometric analysis of global research on the effect of rebar coatings on corrosion resistance and bond strength in reinforced concrete. By employing data-driven methods and visualization tools such as VOS viewer and Cite Space, this analysis identifies key research clusters, citation networks, productive institutions, and geographical trends. Moreover, it reveals the evolution of research themes over time and highlights the most cited publications that have shaped the field. This bibliometric insight will serve as a valuable reference for researchers, practitioners, and policymakers seeking to design more durable and resilient concrete infrastructure.

2. Methodology

This study is designed to comprehensively review, categorize, map, and analyse the existing research articles and book chapters focusing on the effect of rebar coating on the corrosion resistance and bond strength of reinforced concrete. The methodology comprises two main steps as shown in Fig.1: initially, conducting a bibliometric analysis to assess the quantitative aspects of the literature regarding rebar coatings and their impact on reinforced concrete performance, followed by a systematic review analysis to explore the qualitative aspects in detail, starting from types of rebar coatings, their mechanisms of corrosion protection, influence on bond behaviour, and culminating in their implications for the durability and structural performance of reinforced concrete structure.

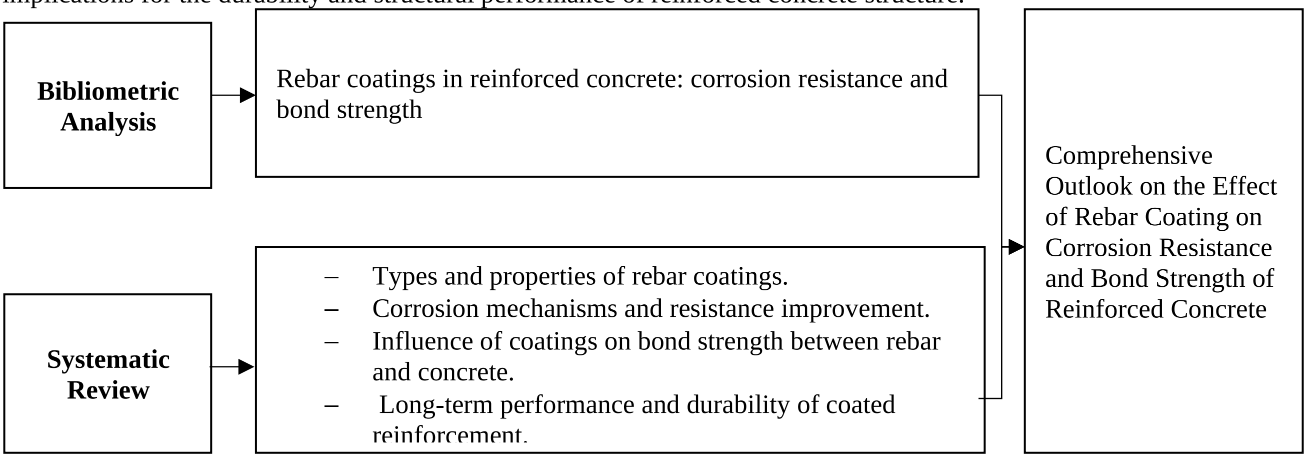

Fig.1. Flow chart of proposed methodology.

The data for this bibliometric analysis were retrieved from the Scopus database, one of the most comprehensive and widely used abstract and citation databases for peer-reviewed literature. The search query was constructed using combinations of relevant keywords such as "rebar coating," "corrosion resistance" "bond strength," and "reinforced concrete." Boolean operators and field-specific filters were applied to refine the results. The final dataset includes articles, conference papers, and reviews published between January 1, 2014, and December 31, 2024.

2.1 Bibliometric Analysis

This review reveals the Effect of rebar coating on corrosion resistance and bond strength of reinforced concrete2014 to 2024. Bibliometric analysis method was employed to fulfil this objective. Additionally, the study adheres to the PRISMA framework [34]–[36]shown in Fig. 2. Bibliometric analysis involves tracking research papers focused on a specific theme and extracting insights by analysing these studies across different parameters. The search in the Scopus database encompassed various search fields, including Title, Abstract, Author Keywords, and Keywords Plus, to identify related publication.

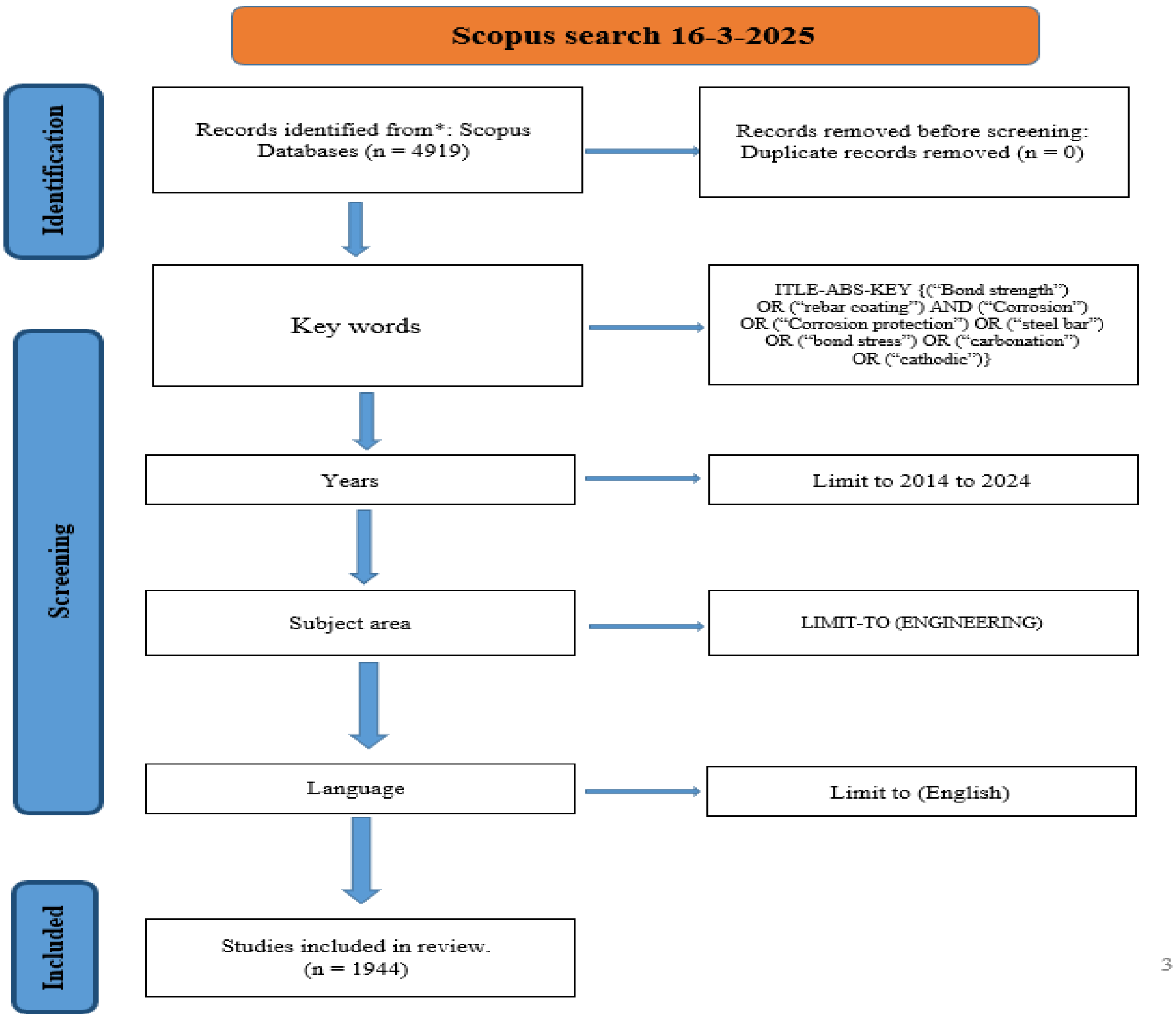

Fig. 2. PRISMA Framework.

2.2 Systematic Review

Numerous reviews have emerged concerning the effect of rebar coating on corrosion resistance and bond strength of reinforced concrete over the period from 2014 to 2024. This review article distinguishes itself by providing a comprehensive and critical bibliometric analysis of advancements in protective rebar coatings and their impact on reinforced concrete durability and structural performance. References were meticulously sourced from databases such as Scopus, Web of Science, Elsevier, and Google Scholar. The selection criteria included all pertinent publications up to January 2024, with the search guided by keywords like “rebar coating,” “corrosion resistance,” “bond strength,” “epoxy-coated reinforcement,” “galvanized steel,” “reinforced concrete durability,” “steel-concrete interface,” and other related terms. The initial search yielded over 1,000 documents, which were then refined based on the relevance of their titles and abstracts, excluding those that did not directly align with the scope of the study. The essential findings drawn from the literature are synthesized and discussed in the following sections. The insights presented in this review are valuable for both academic researchers and industry professionals, as they highlight effective strategies for enhancing the longevity and integrity of reinforced concrete structures. Furthermore, this work contributes significantly to the evolution of sustainable construction practices and offers guidance for regulatory bodies and policymakers aiming to align infrastructure development with the United Nations Sustainable Development Goals (SDGs).

3. Result

3.1 Bibliometric Analysis

Bibliometric analysis is a statistical approach used to quantify and evaluate the emerging trends within a particular field of study. Bibliometric analysis has been applied to evaluate academic outputs across multiple disciplines. The search, conducted on the Scopus database from 2014 to 2025, utilized various search fields such as Author keywords, Title, Abstract, Author, and Keywords Plus. The search employed a combination of keywords using AND/OR logic, including terms like (("Compressive strength") AND (" Reinforced Concrete") OR (" Bars ") OR (" Corrosion") OR (" Steel Corrosion ") OR (" Compressive –strength ") OR (" Fiber Reinforced Plastics ") OR (" Corrosion Resistance ") OR (" Reinforcement ") OR (" Steel Fibers ") OR (" Pull-out Test ") OR (" Bond Stress ") OR (" Concrete ") OR (" Tensile Strength ") OR (" Concrete Construction ") OR ("Bond Behaviours ") OR (" Concrete Beams And Girders ") OR (" Concrete Testing") OR (" Steel Bars ") OR (" Concrete Testing") OR (" Concrete Aggregates ") OR (" Performance ") OR (" Bond ") OR (" Bond Slips") OR (" High Performance Concrete ") OR (" Corrosion Resistant Coatings ") OR (" Durability ") OR (" Adhesion") OR (" Concrete Buildings ") OR (" Chlorine Compounds") OR (" Deterioration") OR (" Bond Length") OR (" Cracks") OR (" Steel Bars ") OR (" Bond Behaviour") OR (" Scanning Electron Microscopy") OR (" Mortar") OR (" Recycling") OR (" Corrosive Effects") OR (" Electrochemical Corrosion ") OR (" Steel Testing ") OR (" Adhesives ") OR (" Fly Ash ") OR (" Basalt ") OR (" Mechanical Properties ")).
The results were assessed based on titles and abstracts to ensure coherence with the article’s theme and core topic. The analysis utilized Scopus analysis and VOS viewer for data visualization. Graphs were generated using Microsoft Excel. Various details were extracted for each document, including (1) the number of documents per year, (2) average citations of articles per year, (3) author keywords and frequently used words in titles, (4) journals of publication for each article, (5) science categories, (6) most cited articles, (7) authors and coauthors for each article, (8) H-index for top 10 authors, (9) affiliation details for authors and coauthors, (10) countries of the authors, and (11) H-index for top 10 journals,. Bibliographic maps were generated using VOS viewer software, encompassing keywords co-occurrence, countries co-authorship maps, and bibliographic coupling for countries and affiliations.
4919 documents were initially identified, with 1944 aligning with the study's theme. These documents were then categorized as follows: 1529 research articles, 38 review papers, 341 conference papers, and 36 documents falling into other categories. The dataset comprises 144 sources and 1723 keywords. The publications obtained showed an average growth rate of 90% per year. The most notable increase was observed between 2021 and 2024, reaching its peak with 349 publications in 2024, as shown in Fig. 3. The average annual citation was 95%, reported in 2024, as

illustrated in Fig. 4. Only 5147 articles were cited for that particular year. Fig. 3 illustrates the fluctuation of journals over the years. Until 2024, the journal "Construction and Building Materials" held the top position, but it was surpassed by the " Journal of Building Engineering," which accumulated a total of 7,051 articles. In terms of the Cite Score (2023) of journals, the "Cement and Concrete Composites" led the rankings with a score of 18.7, followed by " Construction and Building Materials " and " Engineering Structures " with scores of 13.8 and 10.2, respectively, as detailed in Table 1.

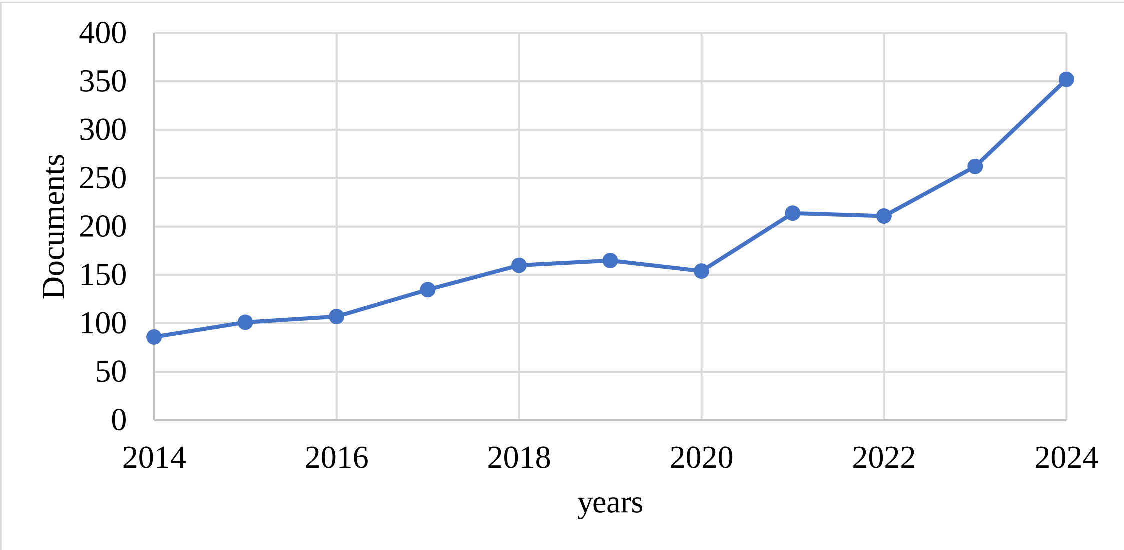

Fig. 3. Distributions by years.

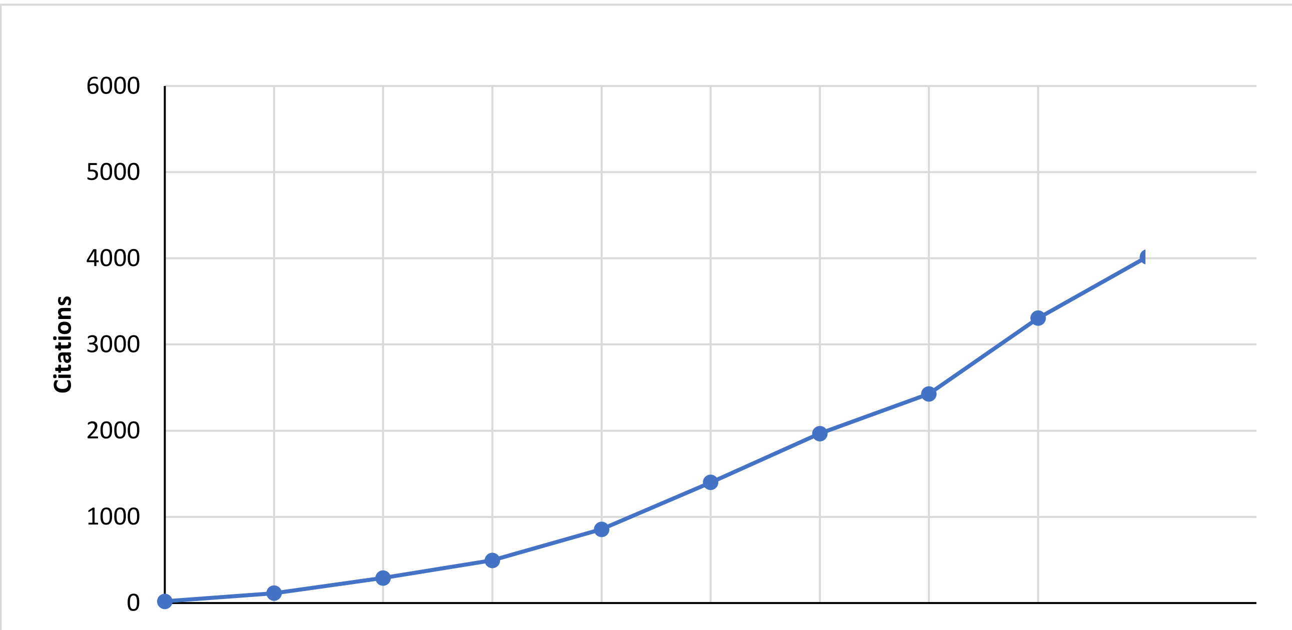

Fig. 4. Average citation per article each year.

TABLE 1.

The Top 20 Highly Productive Journals.

Journal	TP	TC	Cite Score 2023	Most cited publication	Times Cited	Publisher
Construction And Building Materials	15,336	211,152	13.8	Machine learning techniques and multi-scale models to evaluate the impact of silicon dioxide (SiO_2) and calcium oxide (CaO) in fly ash on the compressive strength of green concrete	241	Elsevier
Journal Of Building Engineering	7,051	70,200	10.0	Predictive models for concrete properties using machine learning and deep learning approaches: A review	236	Elsevier
Engineering Structures	6,077	61,732	10.2	Towards next generation design of sustainable, durable, multi-hazard resistant, resilient, and smart civil engineering structures	163	Elsevier
Structures	5,109	29,065	5.7	Efficient training of two ANNs using four meta-heuristic algorithms for predicting the FRP strength	205	Elsevier
Journal Of Materials in Civil Engineering	2,116	12,304	5.8	Temperature Influence on the Bending Performance of Laminated Bamboo Lumber	35	American Society of Civil Engineers
Fib Symposium	-	363	0.2	-	34	NONE
Structural Concrete	1,180	6,586	5.6	Analysis and prediction of the effect of Nano silica on the compressive strength of concrete with different mix proportions and specimen sizes using various numerical approaches	86	John Wiley & Sons
Lecture Notes in Civil Engineering	17,058	17,939	0.8	Deep Neural Network and YUKI Algorithm for Inner Damage Characterization Based on Elastic Boundary Displacement	15	Springer Nature
Cement And Concrete Composites	1,520	28,391	18.7	Recent progress and technical challenges in using calcium sufflaminate (CSA) cement	127	Elsevier
Buildings	6,258	21,439	3.4	The Phenomenon of Cracking in Cement Concretes and Reinforced Concrete Structures: The Mechanism of Cracks Formation, Causes of Their Initiation, Types and Places of Occurrence, and Methods of Detection—A Review	135	Multidisciplinary Digital Publishing Institute (MDPI)
Materials and Structures/Materia et Constructions	754	4,794	6.4	Bond durability between anchored GFRP bar and seawater concrete under offshore environmental conditions	27	Springer Nature
ACI Structural Journal	537	1,701	3.2	Assessment of Sustainability and Self-Healing Performances of Recycled Ultra-High-Performance Concrete	20	American Concrete Institute
Composite Structures	5,011	59,931	12.0	Review on lattice structures for energy absorption properties	215	Elsevier

Journal of Composites for Construction	362	2,682	7.4	Punching Shear Behaviour of FRP Grid-Reinforced Ultra-High Performance Concrete Slabs	45	American Society of Civil Engineers
Journal of Adhesion Science and Technology	632	3,230	5.1	Advances in FSW and FSSW of dissimilar Al-alloy plates	139	Taylor & Francis
Applied Sciences (Switzerland)	44,530	237,130	5.3	ChatGPT for Education and Research: Opportunities, Threats, and Strategies	468	Multidisciplinary Digital Publishing Institute (MDPI)
Key Engineering Materials	4,388	4,533	1.0	A Study on the Machinability of Wire Electrical Discharge Machining of Nickel Alloy Using Taguchi Grey Approach	23	Trans Tech Publications Ltd
Magazine of Concrete Research	396	1,820	4.6	Experimental and numerical analysis of RC beams strengthened with ECC and stainless-steel strips	24	ICE Publishing .Ltd
Advances in Structural Engineering	894	4,441	5.0	Experimental investigation on the bond performance of sea sand coral concrete with FRP bar reinforcement for marine environments	162	SAGE
Journal of Alloys and Compounds	18,791	209,463	11.1	Environmental remediation and sustainable energy generation via photocatalytic technology using rare earth metals modified g-C3N4: A review	166	Elsevier

Concerning scientific categories, 52.8% of the total articles were categorized under Engineering, followed by Materials Science and Physics and Astronomy with 30.0% and 4.0% of the total articles, respectively, as illustrated in Fig. 5. Other notable fields included Computer Science (2.4%), Chemical Engineering (2.0%), Chemistry (1.9%), Environmental Science (1.9%), Earth and Planetary Sciences (1.7%), Energy (1.1%), and Mathematics (0.7%). A minor proportion, representing 1.6%, fell into other scientific categories. The total number of authors across all articles amounted to 159. Notably, “Jin, L.”, and “Du, X..” authored the highest number of articles with 17 contributions. Following closely, “Wu, Z..” contributed 14 articles, while “Xing, F.” authored 13 articles, as shown in Fig. 6 In terms of the authors H-index, “Xing, F.” achieved the highest score of 76, followed by “Du, Xiu Li.” with an H-index of 67, and “Yoo, Doo-Yeol” attained an H-index of 63, as detailed in Table 2.

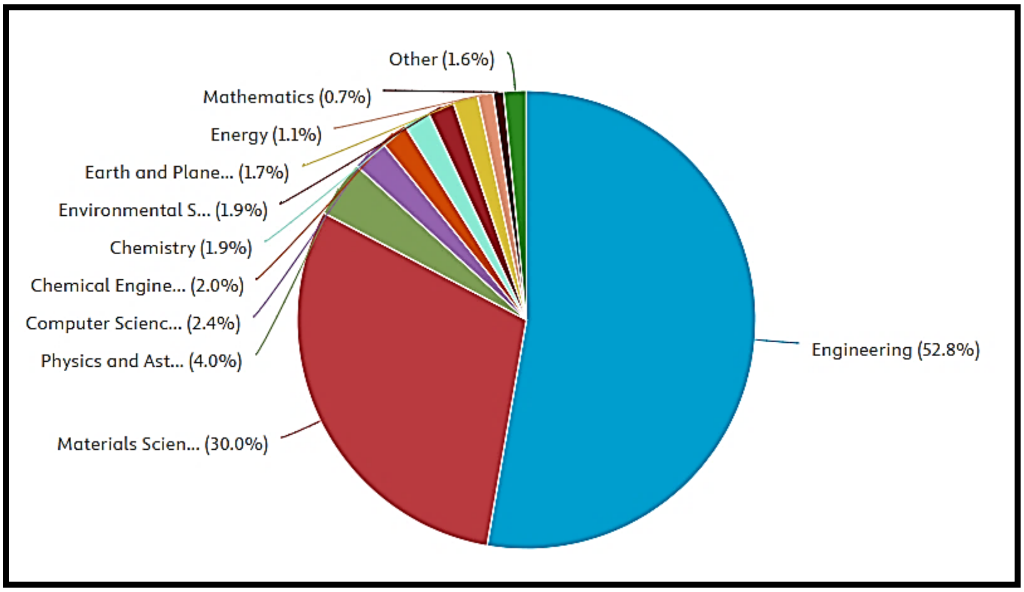

Fig. 5. Research field base publication.

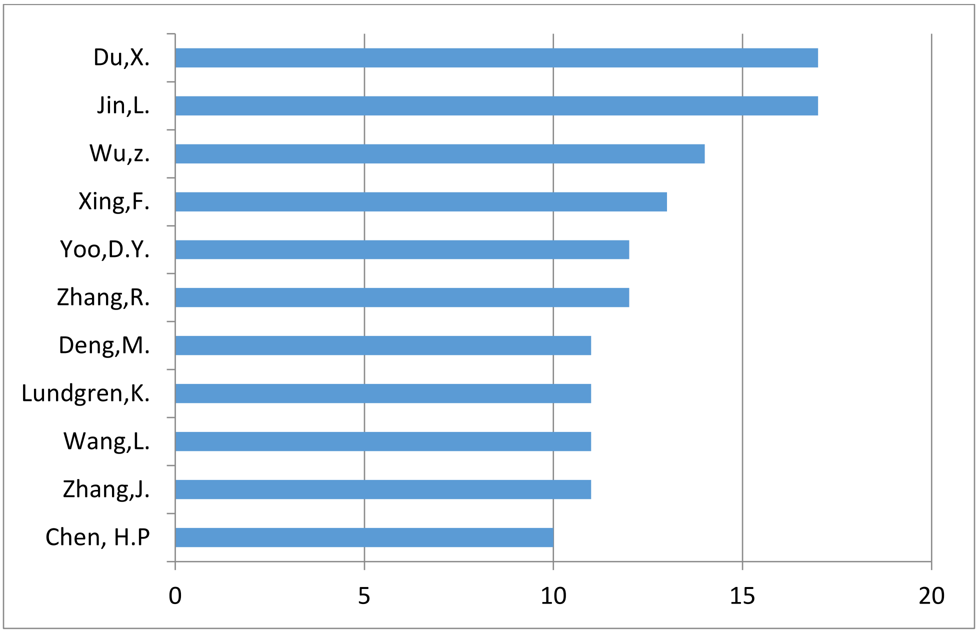

Fig. 6. Top 10 authors based on the number of articles.

TABLE 2

List of the 30 most prolific authors in the effect of rebar coating on corrosion resistance and bond strength of reinforced concrete.

No	author	TP*	h-index	Current affiliation	Country
1	Du, Xiu Li	1,524	67	Beijing University of Technology Beijing, China	China
2	Jin, Liu	417	43	Beijing University of Technology Beijing, China	China
3	Wu, Zhiming	234	36	Zhejiang University of Science and Technology, Hangzhou, China	China
4	Xing, Feng	736	76	Shenzhen University, Shenzhen, China	China
5	Zhang, Rambo	114	24	Beijing University of Technology, Beijing, China	China
6	Yoo, Doo-Yeol	284	63	Yonsei University The institution will open in a new tab, Seoul, South Korea	South Korea
7	Zhang, Jianwei	226	23	Beijing University of Technology, Beijing, China	China
8	Wang, Lei	257	38	Changsha University of Science and Technology, Changsha, China	China
9	Lundgren, Karin	126	36	Chalmers University of Technology, Gothenburg, Sweden	Sweden
10	Deng, Mingle	213	30	Xi'an University of Architecture and Technology, Xi'an, China	China
11	Visintin, Phillip	160	38	The University of Adelaide the institution will open in a new tab, Adelaide, Australia	Australia
12	Chen, Huapeng	183	27	East China Jiaotong University The institution will open in a new tab, Nanchang, China	China
13	Xiong, Zhe	95	26	Guangdong University of Technology The institution will open in a new tab, Guangzhou, China	China
14	Shang, Huaishuai	78	21	Qingdao University of Technology The institution will open in a new tab, Qingdao, China	China
15	Singh, .Bhupinder N	105	24	Indian Institute of Technology Roorkee The institution will open in a new tab, Roorkee, India	India
16	Yang, Tianfeng	185	33	Key Laboratory of Concrete and Prestressed Concrete Structures, Ministry of Education The institution will open in a new tab, Nanjing, China	China
17	Wei, Wei	10	7	Guangdong Construction Polytechnic, Guangzhou, China	China
18	Zhang, Bai	66	25	Changsha University of Science and technology the institution will open in a new tab, Changsha, China	China

19	Lin, Zhibin	106	24	College of engineering the institution will open in a new tab, Arlington, United States	United States
20	Zhou, Ying wu	215	48	Shenzhen university the institution will open in a new tab, Shenzhen, China	China
21	Zandi, Kamyab	75	20	Chalmers University of technology the institution will open in a new tab, Gothenburg, Sweden	Sweden
22	Li, Lijuan	234	52	Guangdong University of Technology The institution will open in a new tab, Guangzhou, China	China
23	Mousavi, Seyed Sina	43	16	Babol Noshirvani University of Technology The institution will open in a new tab, Babol, Iran	Iran
24	Chen, Da	134	26	Hoài university the institution will open in a new tab, Nanjing, China	China
25	Yi, Ju	14	14	Changsha university the institution will open in a new tab, Changsha, China	China
26	Zhang, Jianren	283	38	Changsha University of Science and Technology The institution will open in a new tab, Changsha, China	China
27	He, Shaohua	61	19	Guangdong University of Technology The institution will open in a new tab, Guangzhou, China	China
28	Gao, Denying	351	33	Zhengzhou university the institution will open in a new tab, Zhengzhou, China	China
29	Lin, Hongwei	27	16	Beijing Jiaotong university the institution will open in a new tab, Beijing, China	China
30	Sui, Lili	114	38	Shenzhen university the institution will open in a new tab, Shenzhen, China	China

*TP= Total Publications.

The total number of keywords used in the articles was 1723. "Bond strength " emerged as the most frequently utilized keyword, appearing 1438 times, as depicted in Fig. 7. This was followed by " Reinforced Concrete" observed 754 times, and " corrosion documented 473 times.

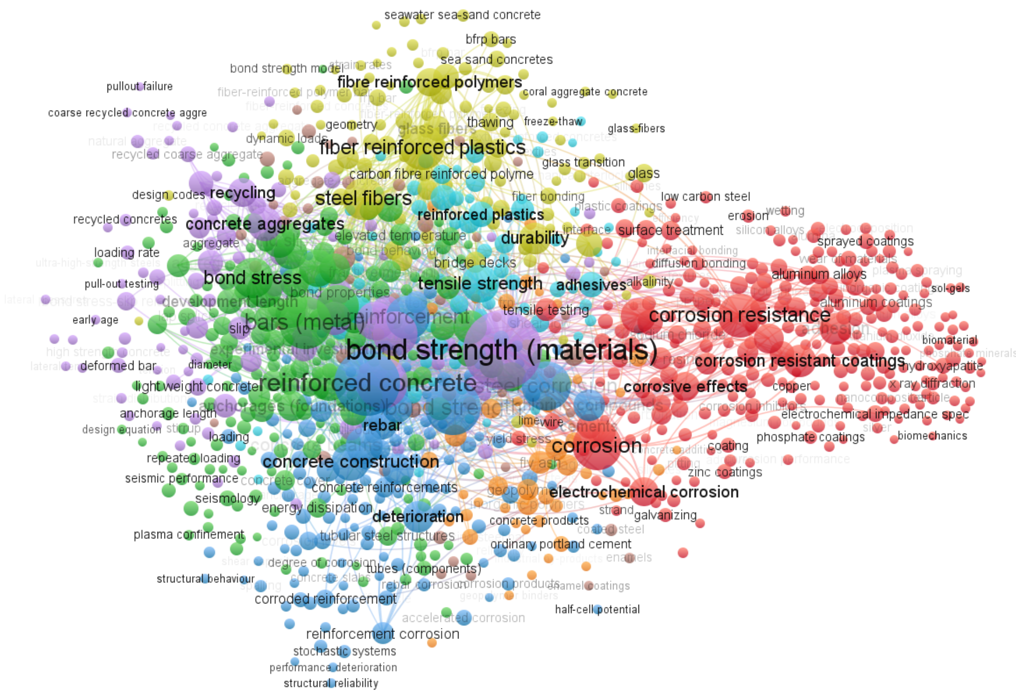

Fig. 7. publications by keywords.

The China exhibited the top contributing country, publishing a total of 813 publications, as illustrated in Fig. 8. Additionally, it demonstrated robust collaborative connections with other countries, as shown in Fig. 9. In second place, United States contributed 182 publications, followed by India ranked third with 165 publications, as detailed in Table 3.

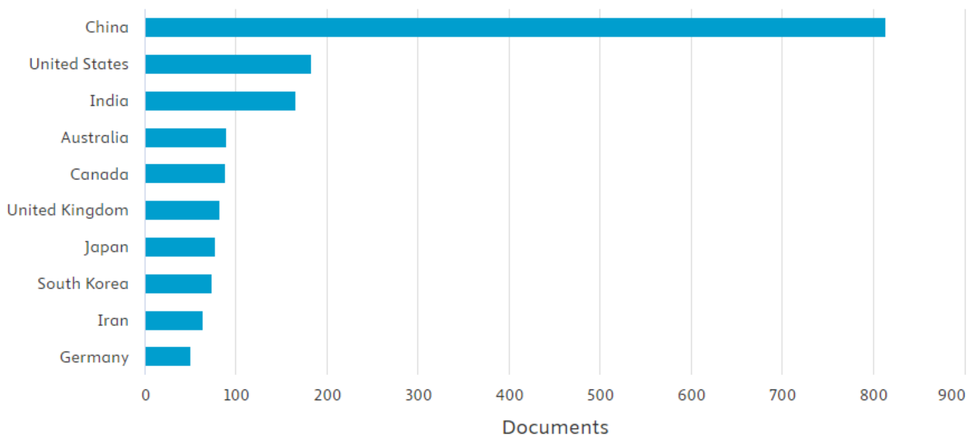

Fig. 8. Most productive countries.

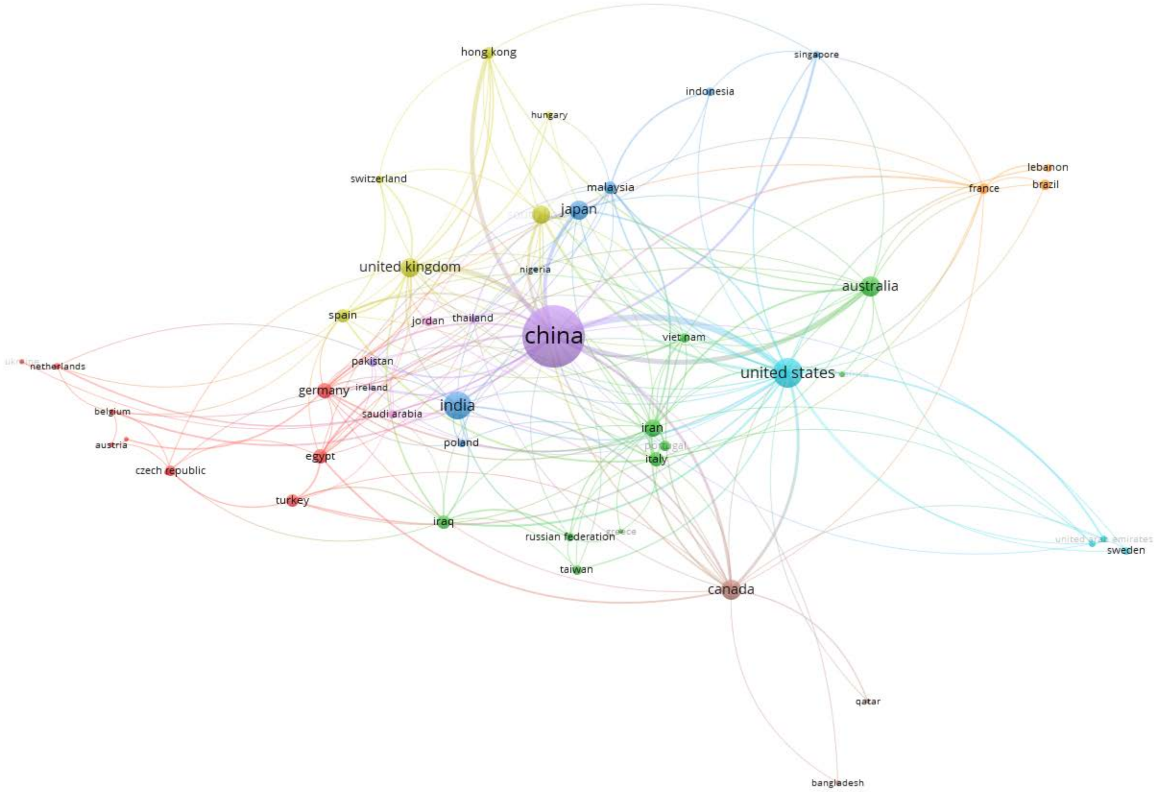

Fig. 9. Co-authorship map of countries.

TABLE 3

List of the 20 most prolific countries in the effect of rebar coating on corrosion resistance and bond strength of reinforced concrete

NO.	Country	Number
1.	China	813
2.	United states of America	182
3.	India	165
4.	Australia	88
5.	Canada	87
6.	United Kingdom	81
7.	Japan	76
8.	South Korea	72
9.	Iran	63

10.	Germany	49
11.	Italy	49
12.	Egypt	43
13.	Spain	40
14.	Iraq	39
15.	Malaysia	36
16.	Turkey	35
17.	Hong Kong	32
18.	France	26
19.	Brazil	25
20.	Czech Republic	25

The most productive affiliation was “Ministry of Education of the People's Republic of China” with 149 articles, followed by “Southeast University” with 60 articles and “Tongji university” with 47 articles as shown in Fig. 10.

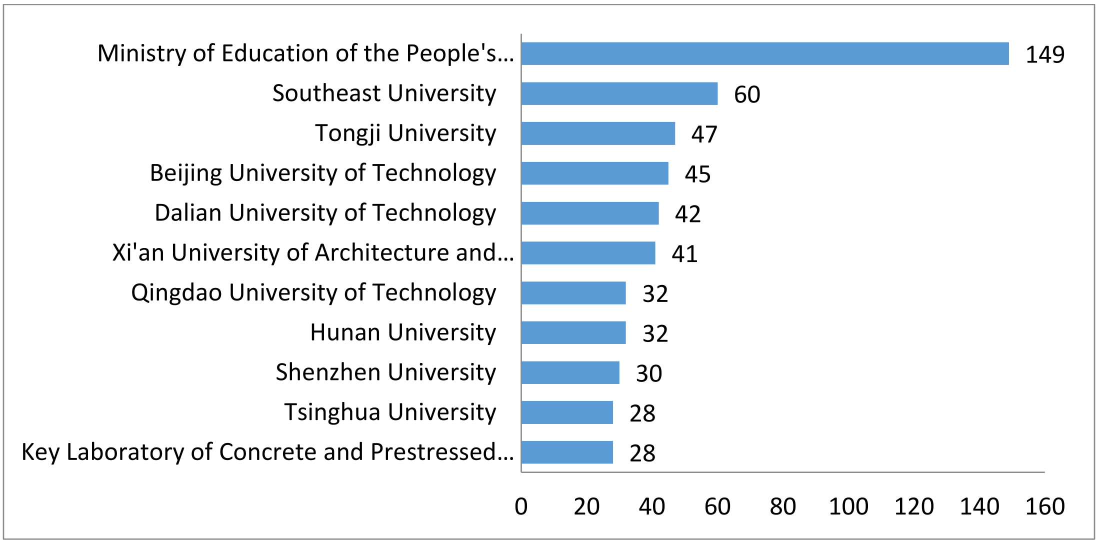

Fig. 10. Top 10 affiliations based on the number of articles.

3.2 Systematic Review

This section presents a systematic review of the global research landscape concerning rebar coatings in reinforced concrete (RC), with a specific focus on corrosion resistance and bond behavior over the period 2014–2024. The objective is to critically analyze the development, effectiveness, and performance evaluation of various coating technologies, as well as their influence on steel–concrete interaction and long-term durability.

3.2.1 Rebar Corrosion and Protective Mechanisms

Corrosion of reinforcing steel remains one of the most serious durability issues affecting RC structures, especially in marine, industrial, or deicing salt-exposed environments. Over the past decade, rebar coating technologies have advanced significantly to mitigate chloride-induced and carbonation-induced corrosion. The primary mechanisms involve creating a barrier to ionic ingress, promoting passivation, or introducing sacrificial protection to steel bars[37]–[39].

3.2.2 Types of Rebar Coatings and Their Performance

A broad spectrum of coating materials has been studied, including:

- Epoxy-Coated Reinforcement (ECR): Widely used since the 1980s, ECR remains a common choice due to its good adhesion and barrier properties. Recent studies [40], [41] have investigated microcrack formation and delamination issues under cyclic loading.
- Zinc-Rich Galvanized Coatings: These provide sacrificial protection and have been shown to perform well in chloride environments. Between 2014–2024, research has emphasized bond behavior optimization and zinc dissolution rates[42], [43].
- Polymer and Hybrid Coatings: Nanocomposite or hybrid polymer coatings with additives such as graphene oxide or silica nanoparticles have gained attention due to their enhanced durability and self-healing capabilities[44]–[46].
- Cementitious and Inorganic Coatings: These coatings are often used in retrofitting or external protection applications and are studied for their compatibility with alkaline environments[47].

3.2.3 Bond Behaviour Between Coated Rebar and Concrete

While coatings improve corrosion resistance, they often alter the bond-slip characteristics between the steel and concrete. Key trends from 2014–2024 include[48]–[50]:

- Reduction in bond strength for thick epoxy layers due to loss of mechanical interlocking.
- Improved bond performance with surface-modified coatings (e.g., roughened epoxy or dual-layer coatings).
- Studies combining pull-out tests, beam-end tests, and numerical simulations to quantify coating impacts on development length and anchorage behavior.

3.2.2 Experimental and Modeling Advances

Significant progress has been made in the testing methodologies and simulation tools used to evaluate coated rebar systems[50], [51]:

- Accelerated corrosion tests (e.g., salt spray, impressed current) are increasingly used to simulate real-life degradation.
- Finite Element Modeling (FEM) and Artificial Neural Networks (ANNs) have been applied to predict corrosion initiation time, bond degradation, and service life of coated RC elements.
- Studies integrating environmental exposure data (e.g., humidity, chloride ingress) with material performance are gaining ground.

4. Discussion

The bibliometric and systematic review analyses conducted in this study provide significant insights into the global research landscape on rebar coatings in reinforced concrete (RC) systems from 2014 to 2024, particularly in relation to corrosion resistance and bond behaviour. The findings highlight the growing interest in sustainable and durable solutions to combat reinforcement corrosion a leading cause of structural degradation and service life reduction in RC infrastructure.

The data reveal a steady increase in scientific output, especially from 2021 to 2024, with China, the United States, and India leading contributions in terms of volume and impact. China's dominance is further underscored by its strong international collaborations, prolific institutions such as Southeast University and Tongji University, and high author productivity. This aligns with the country’s growing investment in infrastructure resilience and materials innovation. The keyword co-occurrence maps demonstrate a research shift from general corrosion mitigation to more specific and advanced topics, such as nano-enhanced coatings, self-healing polymers, and hybrid reinforcement systems.

In terms of coating technologies, epoxy coatings continue to be widely researched, although concerns remain about their long-term adhesion and bond strength, especially under cyclic loading. Galvanized coatings, offering sacrificial protection, are noted for their balanced performance, though challenges related to coating uniformity persist. Recent advancements in nanotechnology, including graphene-based and silica-reinforced coatings, suggest a trend toward multifunctional protective systems capable of providing both corrosion resistance and mechanical robustness. These novel coatings are frequently evaluated using sophisticated characterization techniques such as SEM, EIS, and FTIR.

Bond behaviour remains a nuanced topic within coated rebar research. While some coatings have been shown to reduce bond strength due to altered surface friction and reduced mechanical interlock, others, especially those modified for surface roughness or embedded with particulate matter, have shown neutral or positive effects. Finite Element Modelling (FEM) and Artificial Neural Networks (ANNs) are increasingly used to simulate and predict these interactions, enabling researchers to explore parameters beyond traditional lab testing.

The discussion also underscores the evolution of testing methods. Accelerated corrosion testing has become more standardized, allowing better comparison across studies. Likewise, there is a growing trend of integrating environmental data (e.g., chloride penetration, carbonation depth) with structural performance models to evaluate coating effectiveness under real-world conditions.

Despite these advances, several gaps persist in the literature. First, there is a lack of full-scale field validation studies, which limits the translation of lab-scale results into practical applications. Second, few studies have examined the long-term economic and environmental impacts of different coating systems through life cycle cost (LCC) or sustainability assessment frameworks. Finally, while bond behaviour has been studied extensively, fewer studies explore the combined effect of corrosion and mechanical fatigue, a realistic condition in most RC structures.

In summary, the discussion highlights that the research on rebar coatings in RC systems is at a transformative phase, driven by advances in materials science, computational modelling, and interdisciplinary collaboration. Moving forward, future studies should focus on developing performance-based standards, integrating durability assessments with sustainability metrics, and validating results through real-life structural monitoring and data-driven optimization approaches.

5. Conclusion

This study provides an in-depth evaluation of global research efforts focused on rebar coatings in reinforced concrete, emphasizing corrosion resistance and bond behaviour over the past decade. By integrating bibliometric and systematic review methods, the research identifies the most influential authors, institutions, and technological developments in the field. The results demonstrate the increasing importance of protective coatings in enhancing the durability of RC structures and underscore the need for future interdisciplinary and application-focused research.

Key Conclusions:

1. A notable increase in research activity from 2014 to 2024 highlights growing academic and industrial interest in rebar coating technologies.
2. Epoxy and galvanized coatings remain dominant in research, while advanced coatings such as nanocomposites and hybrid polymers are emerging.
3. Coated rebars improve corrosion resistance but may adversely affect bond behaviour depending on coating type, surface preparation, and environmental exposure.
4. Computational modelling tools such as FEM and ANNs are increasingly applied for simulating long-term behaviour and optimizing design.
5. Research remains concentrated in countries like China, the USA, and India, with strong institutional contributions and international collaboration.

5.1 Contributions to the Study

1. This is one of the first comprehensive studies to combine bibliometric analysis with a systematic literature review on rebar coatings in RC structures.
2. It identifies key research trends, prolific authors, influential journals, and evolving thematic areas within the domain of rebar corrosion protection and bond performance.
3. The study synthesizes performance evaluations across various coating technologies, highlighting their advantages and limitations.
4. It outlines a clear research gap related to field validation, sustainability assessments, and long-term structural performance.

5.2 Recommendations

1. Establish uniform testing standards for assessing bond strength and corrosion resistance of coated rebars under real-world conditions.
2. Promote interdisciplinary collaboration between materials scientists, structural engineers, and environmental experts.
3. Encourage governmental and industrial funding for long-term performance monitoring of coated rebar systems in diverse climates.

4. Incorporate life cycle cost (LCC) and sustainability metrics into design codes and decision-making frameworks.

5.3 Future Work

1. Develop and validate new multifunctional coatings that combine corrosion resistance with enhanced mechanical performance.
2. Expand research into smart coatings that incorporate self-healing and sensing capabilities.
3. Apply AI-driven predictive models using real-time exposure and deterioration data to forecast service life and optimize maintenance.
4. Investigate coating performance in high-performance concrete (HPC), ultra-high-performance concrete (UHPC), and recycled aggregate concrete contexts.
5. Conduct large-scale field trials to bridge the gap between laboratory findings and practical implementation in infrastructure projects.

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