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Evaluating the Research Landscape of Earth Blocks in Sustainable Construction: A Bibliometric Analysis (2000–2024)

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Abstract: *This study presents a comprehensive bibliometric analysis of research on earth blocks—particularly compressed earth blocks (CEBs)—in sustainable construction from 2000 to 2024. Drawing on data from the Scopus database and visualized through tools like VOSviewer, the analysis maps thematic evolution, keyword co-occurrences, and author collaboration networks. Findings reveal a transition from early material characterization to mature themes such as thermal performance, soil stabilization, and life cycle assessment, while highlighting underexplored areas like seismic resilience and modular design. Regional research hubs were identified in South Asia, Sub-Saharan Africa, and Latin America, although international collaboration remains limited. The study provides a data-driven foundation for advancing earth block technologies and promoting their integration into climate-resilient, low-cost, and environmentally sustainable construction practices.*

Keywords: Soil, Earth Block, Compressed Earth Block, Low-Cost Housing, Sustainable

1. INTRODUCTION

The built environment's sustainability is greatly influenced by the construction sector, which makes a change to more economical and ecologically friendly materials necessary. Earth blocks, in particular compressed earth blocks (CEBs), have become a major focus among the many alternatives under investigation because of their potential to lower carbon emissions and embodied energy while utilizing naturally occurring, locally sourced materials. Earth blocks are a low-impact, reusable, and natural building material that fits in nicely with both the growing need for climate-adaptive infrastructure and global sustainability goals. Their adaptability to both urban and rural environments enhances their adaptability and positions them as a workable solution to ecological and socioeconomic problems [1].

To fully realize their potential, it is essential to comprehend the direction and structure of scientific research on earth blocks. A quantitative method for evaluating literature, bibliometric analysis provides a methodical way to gauge the field's intellectual growth. By charting author collaborations, keyword co-occurrences, and publication trends, bibliometric techniques allow for a thorough analysis of previous work while also suggesting areas for future investigation. In addition to identifying the most significant contributors, organizations, and geographical areas, this type of analysis offers insights into fundamental themes, knowledge gaps, and developing fields.

The literature on earth blocks published between 2000 and 2024 is examined in this study using bibliometric analysis. Its main objective is to expose the trends that currently dominate scholarly discourse and the ways in which research on this sustainable material has changed over time. Through the use of data visualizations like evolution diagrams, network maps, and thematic heatmaps, this study aims to provide a broad overview of the field, assisting practitioners and researchers in understanding its current state and future directions.

Material performance (such as strength, insulation, and durability), stabilization techniques, environmental advantages, and socio-technical aspects like cost and cultural acceptability are important research topics. Crucially, the renewed interest in traditional building techniques due to resource constraints and climate action places earth block technology at the nexus of innovation and tradition [2]. The study investigates how the academic literature reflects this intersection.

By highlighting the key themes, contributors, and knowledge trajectories in earth block research, this paper ultimately seeks to offer a road map for scholars, practitioners, and policymakers. By doing this, it supports initiatives to mainstream natural building materials into contemporary construction methods, tackling the housing crisis and climate resilience from a well-founded, fact-based perspective.

2. METHODOLOGY

In order to derive significant insights from two decades of research literature, the bibliometric analysis carried out in this study adheres to a systematic and reproducible methodology. Data

collection, data processing, network visualization, cluster analysis, trend and thematic analysis, and result interpretation are the six main stages of the analysis. With both qualitative and quantitative components, this multipronged approach enables a comprehensive analysis of the academic landscape surrounding earth blocks.

2.1 Data Acquisition

The Scopus database, which is renowned for its extensive coverage of peer-reviewed literature, was used to gather pertinent publications. Terms including "compressed earth blocks," "stabilized soil blocks," "natural building materials," and "sustainable construction" were included in the search query. Filters were used to restrict the dataset to studies that were published between 2000 and 2024, including journal articles, conference papers, and reviews. For additional analysis, bibliographic metadata such as titles, abstracts, keywords, authors, affiliations, and publication years were extracted.

2.2 Data Processing

A thorough cleaning procedure was applied to the raw dataset to guarantee consistency and applicability. Articles that had nothing to do with the sustainability or construction of earth blocks were eliminated, and duplicate entries were eliminated. Disparities in author names or institutional affiliations were fixed, and variations in terminology—such as "CEB" versus "compressed earth block"—were standardized. Following curation, the dataset was formatted to work with bibliometric programs like Biblioshiny and VOSviewer.

2.3 Network Visualization

Co-occurrence and co-authorship network maps were created using VOSviewer to show the connections between keywords, authors, and institutions. Individual research elements (such as authors or topics) are represented by nodes in these visualizations, whereas co-occurrence or collaboration frequency is indicated by edges. In addition to providing a visual representation of disciplinary convergence and intellectual connectivity, the resulting networks assisted in identifying important contributors, research clusters, and significant themes in the field.

2.4 Cluster Analysis

Using modularity-based algorithms on keyword co-occurrence data, thematic clusters were found. Studies with related topics, such as life cycle impacts, stabilization techniques, climate adaptability, or structural performance, were grouped into these clusters. Insights into the division or integration of subtopics within the earth block research landscape were provided by the analysis, which demonstrated how these clusters interact and change over time.

2.5 Trend and Thematics Analysis

Thematic evolution diagrams and overlay maps were used to examine temporal trends. The study followed the development of thematic priorities by breaking the timeline up into discrete periods, starting with early foundational work on soil composition and ending with more recent interests in digital fabrication and carbon neutrality. Topics were categorized using thematic maps into motor, niche, basic, and emerging themes according to their maturity (density) and relevance (centrality) in the literature.

2.6 Discussion of Results

Interpreting the statistical and visual results to derive significant insights was the last stage. The conversation incorporates findings regarding the geographic distribution of research, thematic shifts, and collaboration patterns. These observations serve as the foundation for determining important gaps, new opportunities, and strategic paths for further research and funding in the field of sustainable building technologies.

3. RESULTS AND DISCUSSION

3.1 Network Analysis

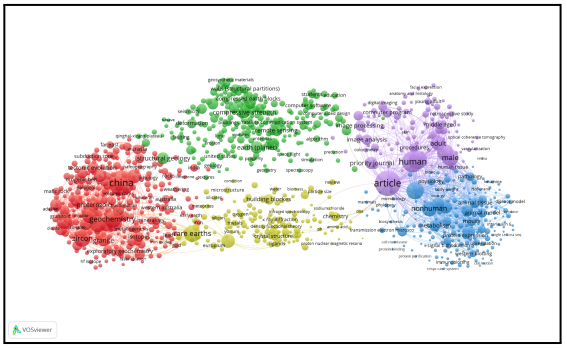

Figure 3.1 Network Visualization of Keywords

A thorough understanding of the main research themes influencing the earth block discourse can be obtained from the keyword network visualization. The key subjects that underpin the field are reflected in dominant nodes like "compressed earth blocks," "sustainable construction," and "stabilized soil." These terms are commonly used in conjunction with others such as "mechanical properties," "thermal insulation," and "soil stabilization," indicating a strong emphasis on material optimization for performance enhancement.

The socio-economic aspect of earth block research is highlighted by an examination of ancillary but related terms like "modular housing," "developing

countries," and "low-cost housing." These connections show that, despite technical issues, there is a lot of interest in how earth blocks can help with housing affordability and advance social justice, particularly in environments with limited resources.

The network also demonstrates the convergence of various disciplines in this field. Interdisciplinary integration is indicated by terms such as "geopolymer," "life cycle assessment," and "natural fibers," which highlight contributions from environmental engineering and materials science. The network also reveals underrepresented nodes, particularly "disaster resilience" and "seismic resistance." Their weak linkages imply that although performance under stable conditions is well-studied, there is still a research gap regarding the behavior of earth blocks under dynamic or extreme loading.

Particularly for areas susceptible to seismic activity, this gap offers a strategic opportunity. By incorporating structural dynamics into earth block construction, their use in more extensive applications, such as resilient housing and post-disaster reconstruction, may become possible. All things considered, the network analysis highlights important avenues for future growth while reaffirming the field's strong foundation [3].

3.2 Density Visualization

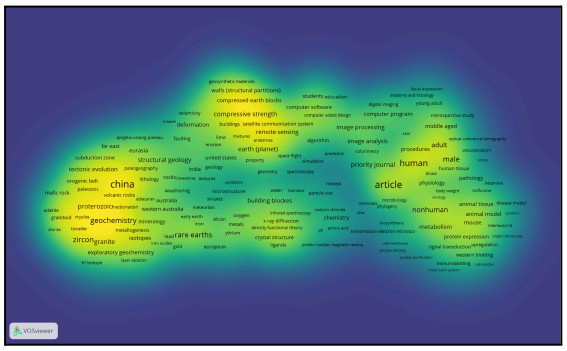

Figure 3.2 Network Visualization of Keywords

By displaying the level of research on different themes, the density visualization gives the keyword analysis an additional dimension. The field's focus on mechanical and structural performance is reflected in high-density regions surrounding keywords like "durability," "compressive strength," and "earth construction." These results imply that scientists have worked hard to measure the physical characteristics of earth blocks, particularly with regard to stability and load-bearing ability.

Conversely, areas with lower density—like "prefabrication," "retrofitting," and "thermal mass"—indicate subjects that are still in their infancy or lack sufficient research. The viability of earth blocks could be further improved in these areas, which represent innovation frontiers, by using innovative construction techniques or climate-responsive designs. The paucity of research on these subjects points to the need for more comprehensive testing frameworks that mimic climatic variability and real-world usage.

Crucially, the outer edges of the density map display terms related to disaster risk, such as "seismic performance" and "resilience." A significant research gap is indicated by their poor representation. It is imperative to look into how earth blocks behave under stress in an era of changing climate and more frequent natural disasters. This is particularly pertinent to the advancement of building codes and general acceptance.

As a result, although the density map validates a solid corpus of knowledge in fundamental material science, it also highlights gaps in the literature. Research bridging the gap between experimental validation and large-scale, robust application of earth block systems is made possible by these low-density zones [4].

3.3 Thematic Evolution

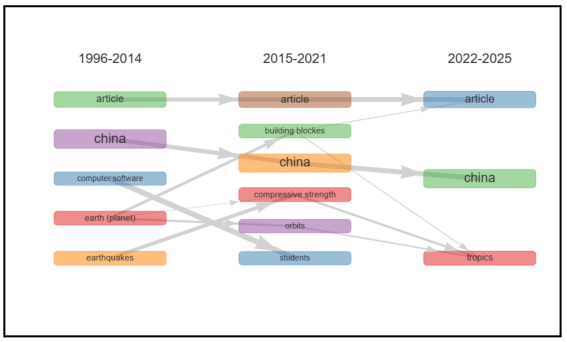

Figure 3.3 Thematic Map Evolution

From 2000 to 2024, the thematic evolution maps chart the evolution of earth block research. Studies in the early 2000s were mostly concerned with basic material characterization; terms such as "soil type," "clay content," and "moisture behavior" were common and reflected an early attempt to comprehend the physical and chemical characteristics of raw materials.

A change toward optimizing earth blocks for safety and functionality, especially through the incorporation of industrial by-products or hybrid stabilizers like lime and fly ash, was marked by the field's maturation toward performance benchmarking between 2010 and 2020, with increased attention to "compressive strength," "thermal comfort," and "cement stabilization."

Most recently, after 2020, research topics have become more in line with the goals of global sustainability. Terms like "life cycle assessment," "carbon footprint," "affordable housing," and "climate resilience" have become more popular. This change is a reflection of a more comprehensive, systems-level strategy that places earth blocks in relation to sustainable development objectives and the circular economy.

Notwithstanding these advancements, there is little thematic overlap between seismic and disaster-resilience topics on the maps. The necessity of closing this gap is highlighted by the increasing frequency of extreme weather events. In the upcoming years, it will be essential to develop simulation models and experimental protocols to test earth block assemblies under dynamic loads [5].

3.4 Thematic Map

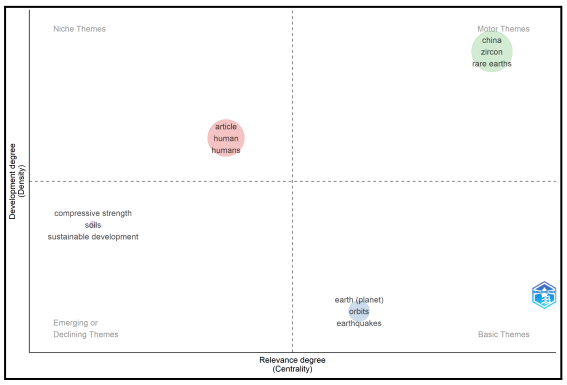

Figure 3.4 Thematic Map of the Study

Research areas are categorized by the thematic map according to their maturity (density) and relevance (centrality). "Compressed earth blocks," "soil stabilization," and "thermal performance" are core topics—those in the Motor Themes quadrant—that are fundamental and keep the field moving forward. Their positioning validates their function as highly influential anchor themes that generate ongoing scholarly interest.

Contrarily, Basic Themes like "environmental impact," "cost analysis," and "resource efficiency" exhibit high relevance but lower density, indicating that they are significant but still in the early stages of development. These topics are essential for integrating policies, especially when it comes to housing initiatives in developing nations and green certification requirements in developed ones.

More specialized topics like "microstructural analysis" and "chemical admixtures," which are highly technical but still only touch on the main conversation, are found in the Niche Themes quadrant. Last but not least, the Emerging Themes quadrant comprises "disaster resilience," "climate adaptation," and "seismic resistance"—themes with low current integration but high future potential.

For stakeholders, this thematic classification provides a strategic guide. While emerging themes require investment in research infrastructure and interdisciplinary collaboration to fully develop, mature areas can be leveraged for immediate application and scaling.

3.5 Author and Country Collaboration

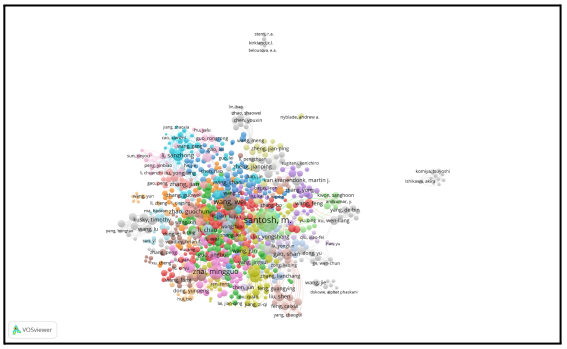

Figure 3.5 Network Visualization of Authors

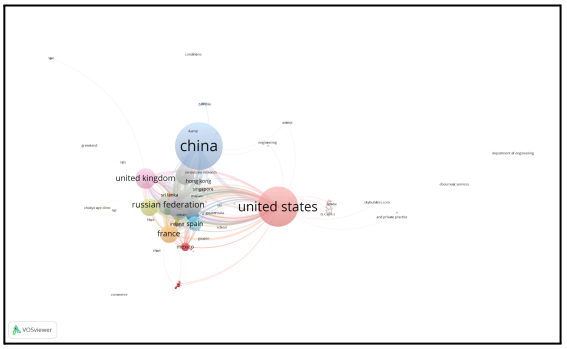

Figure 3.6 Network Visualization of Authors

Earth block research is regionally concentrated, with major contributions from Brazil, Nigeria, India, and portions of Europe, according to collaboration analysis. These areas are driven by the same factors: either a long-standing tradition of earthen construction or an urgent need for affordable housing. Their contributions include both field-based experiments and theoretical research [6].

Several highly collaborative clusters can be seen in author networks, which are frequently centered around universities with robust departments of civil engineering or materials science. But the maps also show that there are still few cross-border partnerships. Growing international networks could speed up testing method standardization and promote knowledge sharing, particularly between the Global South and North.

Interestingly, nations with high seismic risk—like Chile or Japan—are underrepresented. This identifies a chance for focused cooperation with those areas' seismic engineers and legislators. Enhancing these connections could increase the range of applications for earth blocks and guarantee their safe use in regions vulnerable to natural disasters.

Notable is also the lack of interdisciplinary co-authorship with sociologists, urban planners, or climate scientists. In addition to being technically sound, earth blocks would also be socially and environmentally integrated if research were conducted using a more comprehensive approach. To push the limits of what this underappreciated material can offer a world that is warming and urbanizing quickly, such synergies are crucial.

4. CONCLUSION

The research landscape surrounding earth blocks in sustainable construction from 2000 to 2024 was bibliometrically analyzed in this study. By combining co-occurrence network mapping, thematic evolution tracking, and density visualizations, the study provides a thorough analysis of the intellectual structure, collaboration dynamics, and thematic progression within this field. The results validate the increasing interest of academics and practitioners in earth blocks as a viable substitute for traditional building materials, especially in light of global sustainability goals, housing shortages, and climate adaptation imperatives.

The findings show that mechanical characteristics, thermal performance, and material stabilization have been the main areas of research, with "compressed earth blocks" and "sustainable construction" emerging as the most popular keywords. There are still significant gaps in the literature even though it has matured in foundational studies, especially in the areas of performance improvement and soil stabilization. Notably, prefabrication, climate-responsive design, and seismic resilience are understudied topics that offer important prospects for further investigation. Closing these gaps will be essential to expanding the use of earth blocks in more difficult and expansive environmental settings.

Thematic evolution analysis illustrates a positive trajectory: research has progressed from basic material characterization to more sophisticated studies involving life cycle assessments, environmental impact, and integration with circular economy principles. This pattern shows a positive move toward systems-level, holistic thinking. Thematic map, however, also emphasizes the need for more thorough methodological advancement in areas like cost-effectiveness, disaster risk reduction, and regulatory compliance—especially with regard to the use of earth blocks in official construction sectors.

The geographically fragmented nature of the research community is further highlighted by the author and country collaboration analysis. Although regions like South Asia, Sub-Saharan Africa, and Latin America have taken the lead due to practical needs and vernacular knowledge, international and interdisciplinary collaborations are still scarce, and strengthening these networks—especially through partnerships with seismic engineers, urban planners, and policy researchers—will be essential for mainstreaming earth block technologies globally.

In conclusion, this bibliometric analysis offers a data-driven roadmap for advancing research, practice, and policy related to earth blocks. It reaffirms their potential to address pressing sustainability and housing challenges while identifying the research frontiers that must be expanded for broader impact. By combining scientific rigor with traditional wisdom and cross-sector collaboration, earth blocks can play a transformative role in building a more equitable, resilient, and sustainable built environment. Waste stone powder's potential to enhance soil qualities for building applications makes it a viable option for creating affordable and environmentally friendly building materials [7]. Similarly, research into using sludge from poultry slaughterhouse wastewater treatment plants as a partial substitute for cement in concrete shows that it is possible to reuse waste materials to improve the mechanical performance of building composites, highlighting yet another important avenue for sustainable construction [8].

Based on the study's findings, more investigation is advised to examine soil mixtures containing larger proportions of waste stone powder in order to better understand how these factors relate to different geotechnical features. Furthermore, applying machine learning models and other cutting-edge methods to examine and forecast the behavior of these soil mixtures may prove advantageous for subsequent research. To further lessen the impact on the environment and encourage resource efficiency, more research is needed to determine how best to incorporate different waste products, such as sludge from poultry slaughterhouse wastewater treatment plants, into conventional building materials.

These developments will be essential to the global mainstreaming of these sustainable technologies, as will continued initiatives to incorporate earth blocks into the recognized construction industries and promote cross-border and interdisciplinary cooperation.

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