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Visual Analysis of Domestic and Foreign Building Brick Skin Research Based on Citespace

LIU Xingnian, LI Haiying
(School of Architecture and Arts, North China University of Technology, Beijing 100144, China)

Abstract With the progress of the times and the leap of science and technology, the application of brick materials and the research on the brick skin in modern architectural design have shown a dual-track development trend of returning to tradition and innovation. Based on the core collection database resources of Web of Science and the CiteSpace visual analysis tool, this paper constructed and analyzed the spatio-temporal map of keyword co-occurrence network, cluster structure, mutation phenomenon, time course and regional distribution map of building brick skin research. The study revealed that in recent years, the research on brick materials has spanned the study of single material properties and extensively involved in the broad world of construction, especially in the integration of green energy-saving technology, the innovation of fine construction technology of brick skin, and the frontier exploration of digital technology in brick masonry, which has shown particularly significant research vitality and development potential.
Keywords CiteSpace, Building brick skin, Trend of research hotspot, Research review
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Based on the research database of brick materials in the last 2 decades, visual tools can be used to explore the development rules of materials and frontier dynamics of the field. Cityspace software directly displays knowledge structure and tendency. In recent years, researchers focused on theoretical researches and accumulation of practical experience, particularly the deepening researches on the properties of brick materials. However, those on the design strategies of brick buildings from the overall perspective of architecture have been less reported. With the consistent upgrading of science and technology, and the popularization of digital design tools, as well as the innovation of new materials, the attention and demands on brick buildings have risen due to the policies and the higher public requirements on architectural environment aesthetics.

1 Research objects and methods

1.1 Data source

The authors searched "brick skin" in Web of Science, and got 591 papers spanning from 1986 to 2023. To ensure the reliability of data, only those from core collections of Web of Science were cited, and the time limited from January, 2000 to October, 2023, 564 papers were obtained. After deleting 7 non-research papers from journals, interviews and comments, the rest was output in txt. format, including all valid information about the papers, such as references. Then CiteSpace 6.1.6 was used to sort and code the papers as the sample sources of this study.

1.2 Research methods

This study applied literature data analysis and content analysis for the comprehensive research. Literature data analysis used CiteSpace 6.1.6 visual literature data analysis software to sort and code the samples, presented the visual knowledge mapping of the research sample sources, and demonstrated directly the major research hotspots and contexts of the brick materials from the multi-dimensional perspectives of "co-occurrence and clustering" of knowledge mapping and "hotspot burst and timeline development". On the basis of literature data analysis, the content analysis was used to integrate the research development sequence and mainstream views of each time node using both timeline and time zone chart. Then, burst was detected to predict the frontier development tendency of building brick skin, and the study put forward the exploring direction of future building brick skin research.

2 Research objects

Taking the core set database of Web of Science as the basis, CiteSpace was used for the visual analysis, papers were searched from those reported from January, 2000 to October, 2023. Relevant research papers were exported for the visual analysis, with "brick* facade", "brick curtain wall", "masonry facade", "brick screen", "structure", "construction" as the keywords, not "face brick". Through analyzing the reference relationship among these papers, knowledge structure evolution of brick material, hotspot transfer, and cooperation network construction as well as the change of research frontiers could be vividly presented.

Through the statistical analysis of the quantity of published dissertations and their citations each year, it could be found that brick-related researches developed greatly after the year of 2010 (Fig.1).

Citespace was used for the deep data analysis, to generate the nation, national citation distribution ring graph of the citations (Fig.2), color transition was adopted to show the change rules of time dimension: the hue transits from gray to red, paler color indicates earlier time of publication; ring area of each country or region is positively related to the quantity of published dissertations in a specific period, that is, larger ring area represents richer research outputs of this country or region in this field.

The citation year and nation ring graph disclosed that brick material researches originated from the early twentieth century, but relevant literature of those years was less found. It is worth noting that since 2013 researches on brick materials have greatly increased and shown the continuous growth tendency, particularly in Spain, Italy, USA, England, China and Portugal, these countries have devoted actively in brick material researches since then.

Further analysis of the graph showed that China had a relatively higher accumulation of research literature, and showed a higher degree of research activity, which could be proved by the dark purple color of the outer ring. Though large-scale researches in this field were launched relatively later, only after 2017, the development

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speed and fruits were considerable.

3 Domestic and international research reviews

3.1 Theory books

Richard R. Weston in his *Materials, Form and Architecture* put forward a perspective of integrating technical properties of materials and cultural significance, criticized the isolated thinking on building materials and technology, stressed that the selection and use of materials should consider both of its technique and cultural value[1]. Kenneth Frarnptorl in *The Poetics of Construction in Nineteenth and Twentieth Century Architecture* made the material and construction a hot spot in the academic field, and tremendous progress has been made in interior structure, facade properties, spatial performance of materials and relevant construction techniques[2]. Andrea Deplazes collected various aspects of brick materials in *Constructing Architecture*: *Materials, Processes, Structures*, including the mechanical properties of structure, aesthetic expression, construction techniques, and the integrated application of brick and other materials[3]. Günter Pfeifer et al. compiled *Masonry Construction Manual* in 2000, integrated construction techniques and construction engineering practices, and put forward a comprehensive methodological perspective through listing practical project cases involving construction techniques of various materials, including masonry[4]. Linda Block in *Design of the Exterior Wall* (2007) (collected in Detail Series, U + A) disclosed the exterior wall structure, facial texture and microscopic details of brick masonry in an all-around way[5].

3.2 Journal papers

3.2.1 Researches on material properties. Zhang[6] discussed the methods of using waste materials to make bricks, including high-pressure steam made of brick ferric tails, lime and sand, and reusing waste tea, river sediment, waste glass, burnt ash of urban solid waste, sawdust, casting by-product, and waste marmoratum, and tested the physical and mechanical performs of different bricks. This provided new methods of reusing wastes. Li Ruiqing[7] divided bricks into 3 levels from the perspectives of the brick, and the relationship between bricks, analyzed the factors influencing different levels of the bricks, and summarized their effects on different levels of brick buildings.

3.2.2 Formal aesthetics research of brick. Nugraha et al.[8] provided more perspectives for transferring the concept of "Indonesia" specified by the client into the design, and put forward that aesthetics, functions and cultural identity must be considered in the design to achieve the optimal effect and reduce errors and loss. Sun Baoliang[9] established the framework study transversely based on typology, took brick building as a building type that can express its interface, sequence and the elegance of building; and longitudinally explained using the concept of constructivism how brick transfers from a single traditional material to modern facade modes of different types.

3.2.3 Curtain wall research. Joo et al.[10] analyzed the structure, and proposed effective insulation plans for the thermal bridge of curtain wall, and verified the insulation performance of the modified plans through simulation and experiment. Cubel et al.[11] came up with a simplified design of masonry wall with steel tie rod connecting structure. These connections played a significant role in stabilizing the exterior wall of brick buildings.

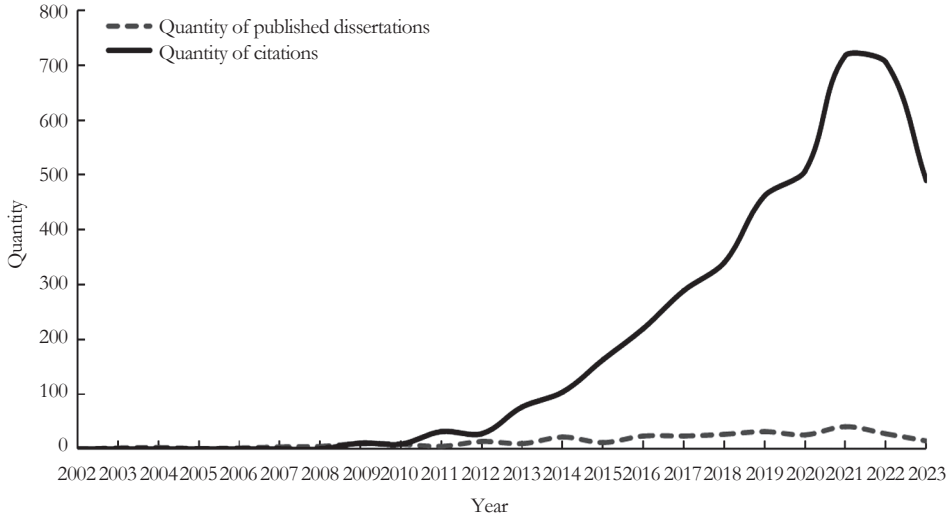

Fig.1 Quantity of relevant published dissertations and citations in Web of Science

4 Research conclusions

4.1 Hotspots

Citespace was used to make the keyword clustering chart (Fig.3), the systematic clustering of keywords helped the authors to disclose and grasp key research topics and evolution sequence of this field. In Fig.3, visual size of each node is positively proportional to its frequency of occurring in the relevant papers, i.e., larger diameter of the ring demonstrates higher using frequency of the keyword in the papers.

Categories of the top keywords for the clustering analysis were set as 10, such as "wall", "building", "construction", "building materials", "performance" and "masonry wall" proved that this field covered multiple interdisciplinary branches like architectural design practices, technical innovation of building materials, and properties of materials. Therefore, researches on masonry structure and its materials not only required the interdisciplinary cooperation, but also consider the influence of multiple factors in exploring specific problems concerning brick facade buildings.

"Soil-structure interaction damage", "simulation", "heat transfer", "challenge life cycle energy", "carbonation", "behavior", these concepts played a significant role in exploring the structural properties of buildings and their environmental response, and improving the sustainable development of buildings. Particularly in the research field of brick materials and brick buildings, these indexes directly related to and deeply influenced the research direction and application effect. It means that researches on the properties of brick materials, and construction techniques of masonry buildings should focus on not only the performance and evolution laws of key technical points, but also the energy consumption in the whole life cycle and also adaptability to the environmental protection standards, and moreover, components of brick materials have potential impact on the durability and overall performance of the building structure.

Through timeline analysis of headline quadratic clustering (Fig.4), keywords from 2008 to 2015 were "thermal bridge", "carbonation", "building material", all were researches focusing on the properties of brick materials. After 2015, keywords turned to "building envelope", "cultural heritage", "green wall", "dynamic recognition", indicating that bricks were studied from the perspective of construction, including the application of green and energy-saving technology, facade construction, and digital technology.

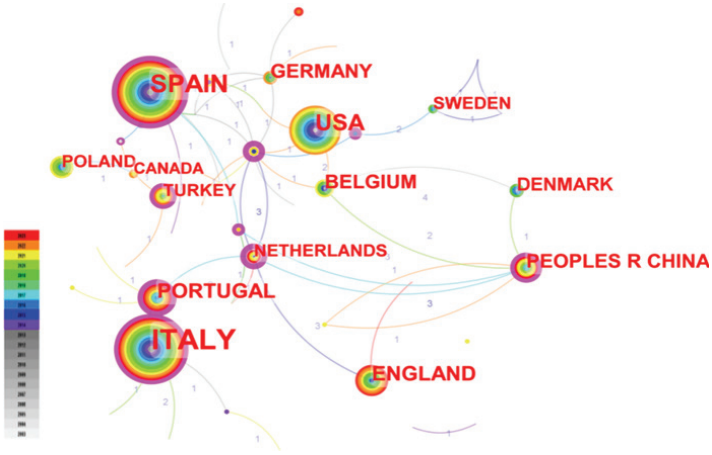

Fig.2 The citation year and nation ring graph of CiteSpace

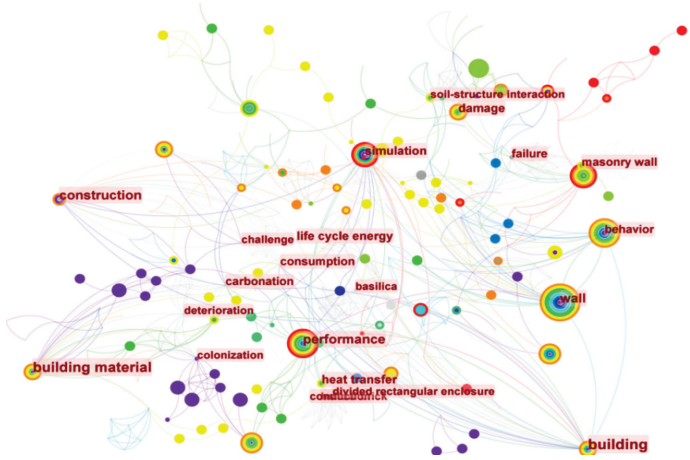

Fig.3 Keyword clustering analysis in CiteSpace

4.2 Research tendency

According to the time sequence, top 15 influential keywords (Fig.5) were selected, among which the blue ones are conventional keywords, and the red ones are bursts. In the earliest references in 2008, the key terms like "masonry wall", "design" and "construction" appeared, indicating that relevant researches at the very beginning were conducted on the basis of building materials and construction system, and these elements had kept the core status in the researches until 2023.

In the application researches on brick building skin, the most important thing is to fully consider the physical and chemical properties of building materials, the overall structural properties of the building, and the construction details. The keywords throughout the time reflected that masonry buildings should closely combine the properties of materials, structural safety, and techniques in both design and construction.

"Masonry wall", "design", "masonry structure", "sensitivity", and "seismic assessment" have gradually become the research focuses, showing the new tendency of masonry building researches, i.e. more attention on the integration of structural design optimization, efficiency of building materials, green and environment-friendly properties. These keywords implied the deep concern on the modification of structural reliability of buildings, and technical innovation, and also reflected that the society not only focused on the improvement of living quality in the construction field, but also pursued environmental protection and energy saving consistently.

4.3 Conclusion

In conclusion, researches on brick material and its application in the past years focused

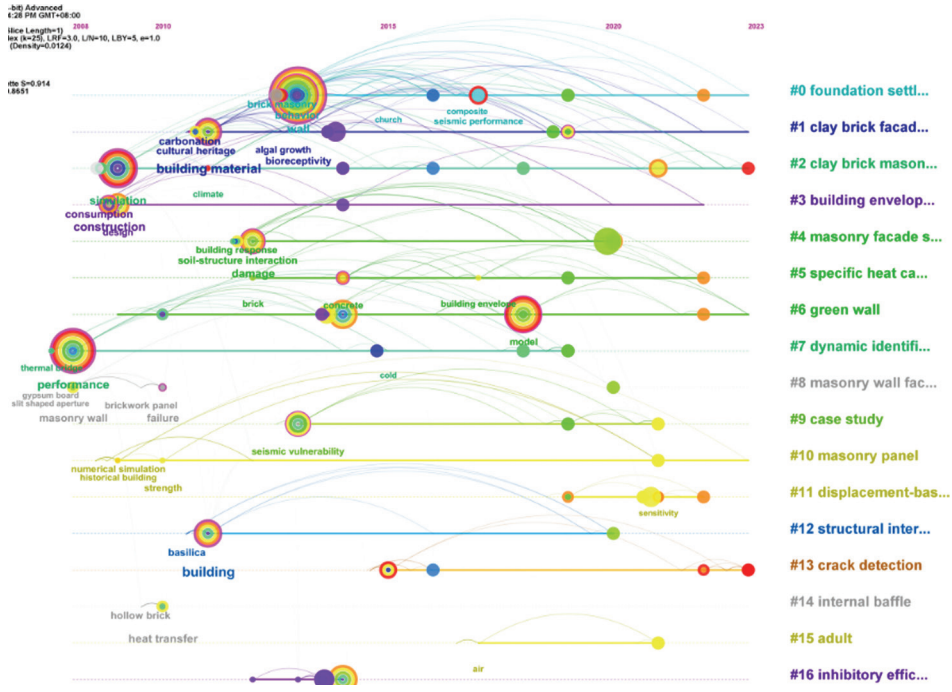

Fig.4 Time map of keyword clustering in CiteSpace

Keyword	Year	Strength	Begin	End	2008–2023
Failure	2010	1.65	2010	2013	
Damage assessment	2012	1.83	2012	2015	
Construction	2009	1.62	2013	2015	
Colonization	2013	1.60	2013	2014	
System	2014	1.65	2016	2018	
Model	2018	3.37	2018	2020	
Scismic vulnerability	2013	1.62	2018	2019	
Damage	2012	2.78	2019	2023	
Mold growth	2019	1.57	2019	2021	
Masonry wall	2008	2.33	2020	2021	
Design	2009	2.21	2020	2023	
Masonry structure	2020	1.78	2020	2023	
Interior insulation	2021	2.57	2021	2023	
Sensitivity	2021	1.71	2021	2023	
Seismic assessment	2021	1.71	2021	2023	

Fig.5 Top 15 keywords with the strongest citation bursts in CiteSpace

on the essence of building materials and the core of construction system until 2023. The researches also expanded to the construction level, and attached more importance to the green and energy-saving, facade construction technique, and digital application. At the meantime, keywords of the recent research hotspots clearly demonstrated that the design and construction of masonry wall buildings must give comprehensive consideration to the optimization of material properties, structural safety, and technical innovation.

References

[1] Weston, R. R. (2005). *Materials, Form and Architecture* (Trans. by Fan, S. N., Chen, J. L.). Beijing: China Water & Power Press. (First published in 2003)

[2] Frampton, K. (2007). *Studies in Tectonic Culture*: *The Poetics of Construction in Nineteenth and Twentieth Century Architecture* (Trans. by Wang, J. Y.). Beijing: China Architecture & Building Press. (First published in 2001)

[3] Deplazes, A. (2005). *Constructing Architecture*: *Materials*, *Processes*, *Structures*. Berlin: Springer Science & Business Media.

[4] Pfeifer, G., Ramcke, R. & Achtziger, J. et al. (2004). *Masonry Construction Manual*. Dalian: Dalian University of Technology Press. (First published in 2001)

[5] Block, L. (2007). *Design of the Exterior Wall* (Trans. by Zhang, Y.). Shenyang: Liaoning Science and Technology Press.

[6] Zhang, L. (2013). Production of bricks from waste materials: A review. *Construction and Building Materials*, (47), 643-655.

[7] Li, R. Q. (2013). *Pattern language of bricks* (Master's thesis). Retrieved from China National Knowledge Infrastructure.

[8] Nugraha, L. A., Murwonugroho, W. (2021). Contemporary aesthetics of exposed bricks for buildings' facade and interior. IOP Conference Series: Materials Science and Engineering. *IOP Publishing*, *1098*(6), 062048.

[9] Sun, B. L. (2008). *Research on the Language of "Brick Buildings"* (Master's thesis). Retrieved from China National Knowledge Infrastructure.

[10] Joo, N. Y., Song, S. Y. (2023). Improvement of thermal insulation performance of precast concrete curtain walls for apartment buildings. *Energy and Buildings*, (296), 113350.

[11] Cubel, F., Roldan, J., Vercher, J. et al. (2014). Study of the mechanical behavior against horizontal forces of self-supporting facades. *Advanced Materials Research*, (1041), 27-30.

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(Continued from P46)

perspectives. However, the number and scope of literature screened in the database are limited, and further expansion and improvement of the screening work are needed in the future to comprehensively explore the research on the thermal comfort of urban block landscape environment.

References

[1] Zhao, M. M., Feng, L. & Guo, S. et al. (2018). Impacts of landscape patterns on the dynamic changes of thermal comfort in Nanjing City. *Resources and Environment in the Yangtze Basin*, *27*(8), 1712-1724.

[2] Chaomei, C., Kevin, W. & Boyack. (2010). Visualizing knowledge domains. *Annual Review of Information Science & Technology*, *37*(1), 179-255.

[3] Chen, Y., Chen, C. M. & Liu, Z. Y. et al. (2015). The methodology function of CiteSpace mapping knowledge domains. *Studies in Science of Science*, *33*(2), 242-253.

[4] Sandrine M. D., Vanessa, R. & Peng, F. (2012). The drafting of the future international climate regime: From the Copenhagen Accord to the Cancún Accords. *Journal of Shanghai University* (*Social Sciences Edition*), *29*(2), 1-14.

[5] Editorial Department.(2019). 2018 global climate change and health summit. *Chinese General Practice*, 22(8), 7.

[6] IPCC. *Climate change 2014*: *Mitigation of climate change*. Cambridge: Cambridge University Press.

[7] Zhao, R. Y., Xu, L. M. (2010). Development and evolution of bibliometrics and knowledge graph of research frontiers. *Journal of Library Science in China*, (36), 60.

[8] Yang, J. Y., Zhang, T. & Tan, Y. (2014). Research on urban wind environment: technology evolution and integration of evaluation systems.*South Architecture*, *161*(3), 31-38.

[9] Derek, J., Price, D. S. (1965). Networks of scientific papers. *Science*, (149), 510.