Research on Reconstruction of Historical Buildings: Bibliometric Studies in International Journals

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Abstract: Various research on the reconstruction of historical buildings has been carried out by researchers from various countries. To find out about its progress, it is necessary to use bibliometric analysis to map studies related to the reconstruction of historical buildings. The aim of this study is to highlight high-impact research related to the reconstruction of historical buildings published in international journals. Based on these results, research opportunities related to this topic in the future can be seen. Bibliometric analysis was performed using the VOSviewer application. Data retrieval for articles related to the reconstruction of historical buildings was carried out on the Scopus database and filtered according to the research and language fields which meant that 137 documents were obtained. The results of the study indicate that the number of articles that discuss this topic have exhibited a significant development. The citation of publications related to this topic are from journals rather than conference papers. Furthermore, the country that contributed the most articles was Italy. Finally, research related to this topic can be grouped into four categories with the current trends in research being towards urban planning, office building, masonry materials, history, virtual reconstruction, and sustainable development. The results of this bibliometric study are expected to provide an overview for future researchers to investigate matters that have still not been much discussed in research on the reconstruction of historical buildings.

***Index Terms*—bibliometric, building, heritage, reconstruction, research**

I. Introduction[1]

RECONSTRUCTING historical buildings refers to the reforming of the original state of buildings of historical interest that have been lost due to natural and human disasters, based on iconographic, written evidence and remaining materials [1]. Reconstruction is defined as an effort to return an object to its original state [2]. There are several reasons why the reconstruction of historical buildings is carried out, including the desire to restore national identity or pride, to improve interpretation, to support education, to increase public attention, as a symbol of reconciliation, or because of the symbolic value of buildings in the urban landscape [3].

Reconstruction and restoration of historical building structures requires a scientific approach and knowledge of the cultural background [4]. Methodological approaches that can be used to reconstruct the buildings include conducting historical research, for example through maps, photographs, archaeological research and art history [5], [6], then proceeding by looking at architecture and construction (facade, inner space, construction techniques, selection of materials, and building's surroundings); and ending with the design and reconstruction [5].

Various research on the reconstruction of historical buildings has been previously carried out. To find out about how this research has developed, it is necessary to map the research that has been related to the reconstruction of historical buildings through bibliometric analysis. By carrying out this kind of analysis, we can explore how research has developed and find trends and opportunities for further research in this field. In addition, through bibliometric analysis, we can also see the dominant contribution of each author as well as each country.

We retrieved data on articles from the Scopus database. This retrieval was carried out on 14th February 2021 and yielded 137 articles. Bibliometric analysis was performed using the VOSviewer application. The aim of this study is to highlight high-impact research related to the reconstruction of historical buildings published in international journals. Based on the bibliometric analysis, a

picture is obtained related to: 1) publication structure and citations; 2) development of research on the reconstruction on historical buildings over time; and 3) opportunities related to this research that present themselves.

II. Research Method

This study used the Scopus database to retrieve articles related to the reconstruction of historical buildings. We used Scopus as the source of articles because this database contains abstracts and citations that are evaluated by independent parties who are experts in their scientific fields. Scopus has comprehensive metadata coverage including document types, abstracts, keywords, and index terms, cited references, affiliation data, author profiles and other metadata (scopus.com).

We used the keywords "reconstruction", "building", "heritage" and "architecture" in the paper search process. There are 331 papers that use these words. To avoid biased retrieval results, we screened these papers and have only use papers that are in the "engineering" and "art and humanities" areas and use English in their documents. In addition, we also only used types paper which were from journals or were conference papers. The final number of papers obtained for analysis in this study was 137 documents.

III. Results and Discussion

A. Structure of Publications

Publications related to the reconstruction of historical buildings show an increasing trend over time. Table 1 shows this progress in terms of the number of documents related to this topic in a five-year period. In the last period (excluding 2021), the number of articles published has almost doubled, from 38 to 74.

TABLE I
Trends Seen In Articles On Reconstruction Of Historical Buildings Over Time

Period*	No. of Documents	Average per year
2016 – 2020	74	15
2011 – 2015	38	10
2006 – 2010	17	4
2001 - 2005	5	2
<2001	1	1

*exclude 2021 (2 document)

This shows that researchers' interest in researching the reconstruction of historical buildings has been increasing over time. When viewed from the average number of articles published each year, a significant increase can be seen. The media used to publish research related to the reconstruction of historical buildings is quite balanced between conference papers (63 documents) and journals (74 documents).

As for journal contributions on the topic of reconstructing historical buildings, Table 2 displays the number of documents published in each journal. In general, the source type that tends to publish more articles on the reconstruction of historical buildings is the conference paper. The top three sources that published articles on this topic were the result of conferences.

TABLE II
Number Of Articles On Historical Building Reconstruction In Journals/Conference Papers (The Ten With The Most Articles)

No.	Source	No. of Documents	Source Type
1	WIT Transactions on The Built Environment	11	Conference paper
2	IOP Conference Series: Materials Science and Engineering	9	Conference paper
3	Advanced Materials Research	6	Conference paper
4	DISEGNARECON	5	Journal
5	Ega Revista De Expresion Grafica Arquitectonica	5	Journal
6	International Journal of Architectural Heritage	4	Journal
7	Lecture Notes in Civil Engineering	4	Journal
8	Applied Mechanics and Materials	3	Conference paper
9	Procedia Engineering	3	Conference paper
10	Proceedings of SPIE - The International Society for Optical Engineering	3	Conference paper

TABLE III
Number Of Source Citations Related To Reconstruction Of Historical Buildings (The Ten Sources With The Most Citations)

No.	Source	No. of Documents	No. of Citations
1	Journal of Cultural Heritage [7]	1	124
2	International Journal of Architectural Heritage [8]–[11]	4	36
3	Journal of Applied Engineering Science [12]	1	36
4	International Journal on Interactive Design and Manufacturing [13], [14]	2	25
5	Computers and Graphics (Pergamon) [15]	1	18
6	Procedia Engineering [7], [16], [17]	3	11
7	Proceedings of SPIE - The International Society for Optical Engineering [18]–[20]	3	9
8	Journal of the Society of Architectural Historians [21]	1	8
9	DISEGNARECON [22]–[26]	5	7
10	Journal on Computing and Cultural Heritage [27], [28]	2	7

Table 3 shows the top ten sources which have the biggest implications, seen from the number of citations of related

documents in those sources. Based on the list of sources in this table, it can be seen that the number of citations is higher in journals than in conference papers (only numbers 6 and 7). This shows that publications in journals are more accessible to readers than conference papers.

To see the implications of each article, Table 4 shows the 10 highest number of citations for each one.

TABLE IV
NUMBER OF PAPER CITATIONS RELATED TO RECONSTRUCTION OF HISTORICAL BUILDINGS (THE TEN PAPER WITH THE MOST CITATIONS)

No.	Author	Title*	No. of Citations
1	Yilmaz H.M. (2007) [29]	Importance of digital close-range photogrammetry in documentation of cultural heritage.	124
2	Murgul V. (2014) [12]	Solar energy systems in the reconstruction of heritage historical buildings of the northern towns.	36
3	López F.J. (2017) [9]	A Framework for Using Point Cloud Data of Heritage Buildings Toward Geometry Modeling in a BIM Context.	28
4	Bellotti F. (2011) [15]	An architectural approach to efficient 3D urban modeling.	18
5	Stefani C. (2010) [13]	Time indeterminacy and spatio-temporal building transformations.	18
6	Lounsbury C.R. (1990) [21]	Beaux-Arts Ideals and Colonial Reality.	8
7	Amakawa J. (2018) [30]	New Philadelphia: using augmented reality to interpret slavery and reconstruction era historical sites.	7
8	Adembri B. (2016) [31]	3D digital models for documenting, learning and analyzing architecture and construction in the ancient world.	7
9	De Luca L. (2014) [14]	A complete methodology for the virtual assembling of dismounted historic buildings.	7
10	Branfoot C. (2013) [32]	Remaking the past: Tamil sacred landscape and temple renovations.	7

*for the full titles, see the references below

Every country has its historic buildings. The effort to reconstruct historical buildings in each country cannot be separated from its role in showing the national identity or pride of the country. Therefore, Table 5 shows the contribution of each country in terms of published papers on the reconstruction of historical buildings. When viewed from the number of citations, the country with the most cited papers was Turkey (not shown in Table 3) with 3 papers and 130 citations.

Italy's position as the largest contributor to articles on reconstructing historical buildings is not surprising. Italy is the country with the largest number of cultural sites in the world with a total of 55 sites. The existence of historical sites in Italy encourages researchers to conduct research related to those historical buildings. On the other hand, even though Spain and France are ranked 3rd and 5th, their contribution of articles related to the reconstruction of historical buildings is still below the countries that have fewer sites than them. Therefore, research opportunities for the reconstruction of historical buildings are quite extensive in these two countries.

TABLE V
NUMBER OF ARTICLES ON HISTORICAL BUILDING RECONSTRUCTION CONTRIBUTED IN EACH COUNTRY (TEN MOST)

No.	Country	Rank*	No. of Documents	No. of Citations
1	Italy	1	31	56
2	China	2	9	8
3	United Kingdom	8	9	31
4	United States	11	9	21
5	Russian Federation	9	7	40
6	Czech Republic	21	6	9
7	Spain	3	6	32
8	France	5	5	33
9	Brazil	13	4	0
10	Croatia	29	4	1

*ranking of the countries with the largest number of cultural sites around the world[2]

B. Research Trends on Historical Building Reconstruction

To see the development of research on the reconstruction of historical buildings, the authors used keywords provided by themselves and journals. The search results with VOSviewer are shown in Table 6. Because the searches carried out were related to the topics of reconstruction, building, heritage, and architecture; we do not display these four keywords in Table 6.

TABLE VI
THE OCCURRENCE OF KEYWORDS IN ARTICLES ON HISTORICAL BUILDING RECONSTRUCTION

No	Keywords	Occu-rence	No	Keywords	Occu-rence
1	image reconstruction	17	14	reconstruction (structural)	7
2	architectural design	16	15	history	6
3	architectural heritage	16	16	religious buildings	6
4	historic preservation	15	17	earthquakes	5
5	maintenance	15	18	masonry	5
6	virtual reconstruction	10	19	masonry materials	5
7	urban planning	9	20	military operations	5
8	heritage conservation	8	21	modern architectures	5
9	historic building	8	22	office buildings	5
10	virtual reality	8	23	Roofs	5
11	3d computer graphics	7	24	sustainable development	5
12	3d reconstruction	7	25	timber	5
13	3d modeling	7			

Based on Table 6, it is found that research on the reconstruction of historical buildings is dominated by image reconstruction, architectural design, and historical preservation. In addition, based on this table, it can also be concluded that research on this topic is mostly carried out in terms of sophisticated visual technology, including virtual reconstruction, virtual reality, and three-dimensional computer graphics.

To see this research trend, Figure 1 shows the development of articles over time. It shows that currently there is a tendency to research urban planning, office building, masonry materials, history, virtual reconstruction, and efforts towards sustainable development (yellow line in the figure).

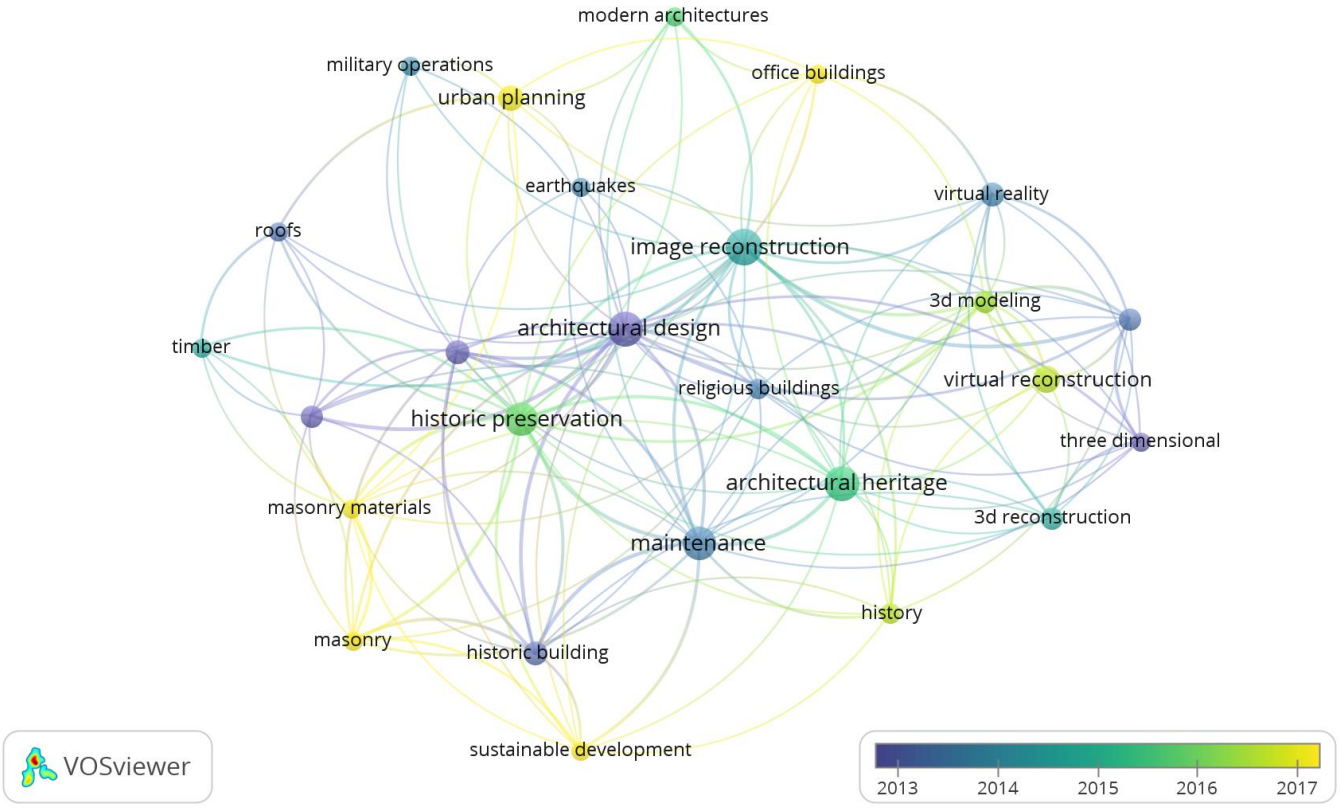

Figure 1. The development over time of research topics related to reconstruction of historical buildings.

To see possible research opportunities in the future, we can look at the limited keywords discussed in the article. This is shown in Figure 2, where the bolder yellow color indicates the degree of saturation on this topic. According to Figure 2, topics that are rarely discussed in historical building reconstruction research include masonry, masonry materials, sustainable development, history, 3D reconstruction, modern architecture, military operations, roofs, and timber.

Furthermore, the clustering process of each of these keywords is carried out (Figure 3) and the details are displayed in four colors. The red cluster (Figure 3) consists of 10 keywords, namely 3D modeling, 3D reconstruction, architecture heritage, history, image reconstruction, religious building, 3D computer graphics, virtual reality, and virtual reconstruction. Based on the keyword items presented, we named this cluster the three-dimensional reconstruction cluster. The green cluster (Figure 3) consists of seven keywords, namely architecture design, earthquakes, heritage conservation, military operations, modern architectures, office building, and urban planning. We call this cluster the conservation of cultural areas from damage.

The blue cluster (Figure 3) consists of six keywords, namely historic preservation, masonry, masonry materials, reconstruction (structural), roof, and timber. We call this cluster the reconstruction cluster for brick building structures. The yellow cluster (Figure 3) has three keywords, namely historic buildings, maintenance, and sustainable development. The last cluster we call the historic building maintenance cluster.

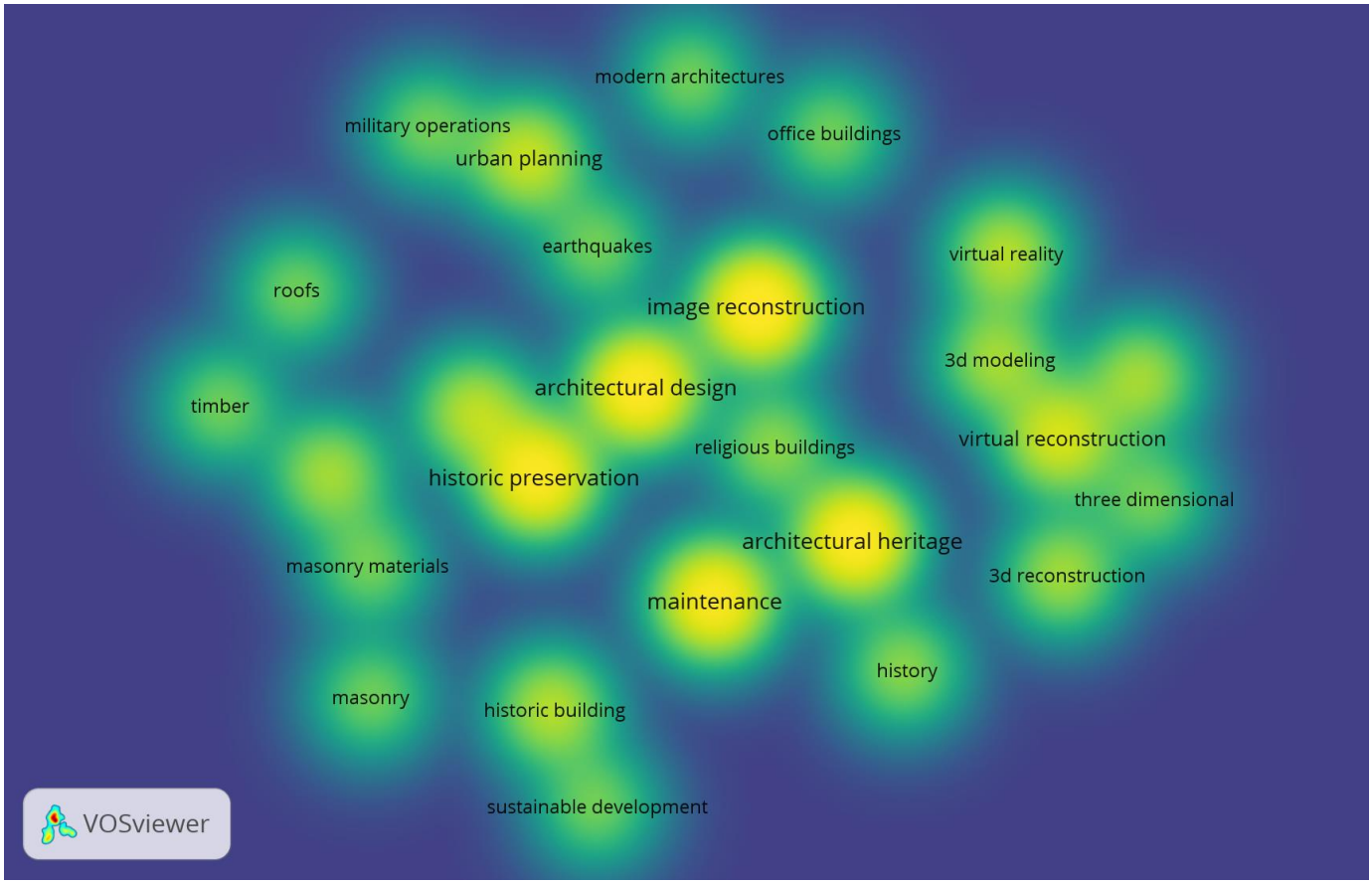

Figure 2. The level of saturation of historical building reconstruction research based on the number of keywords.

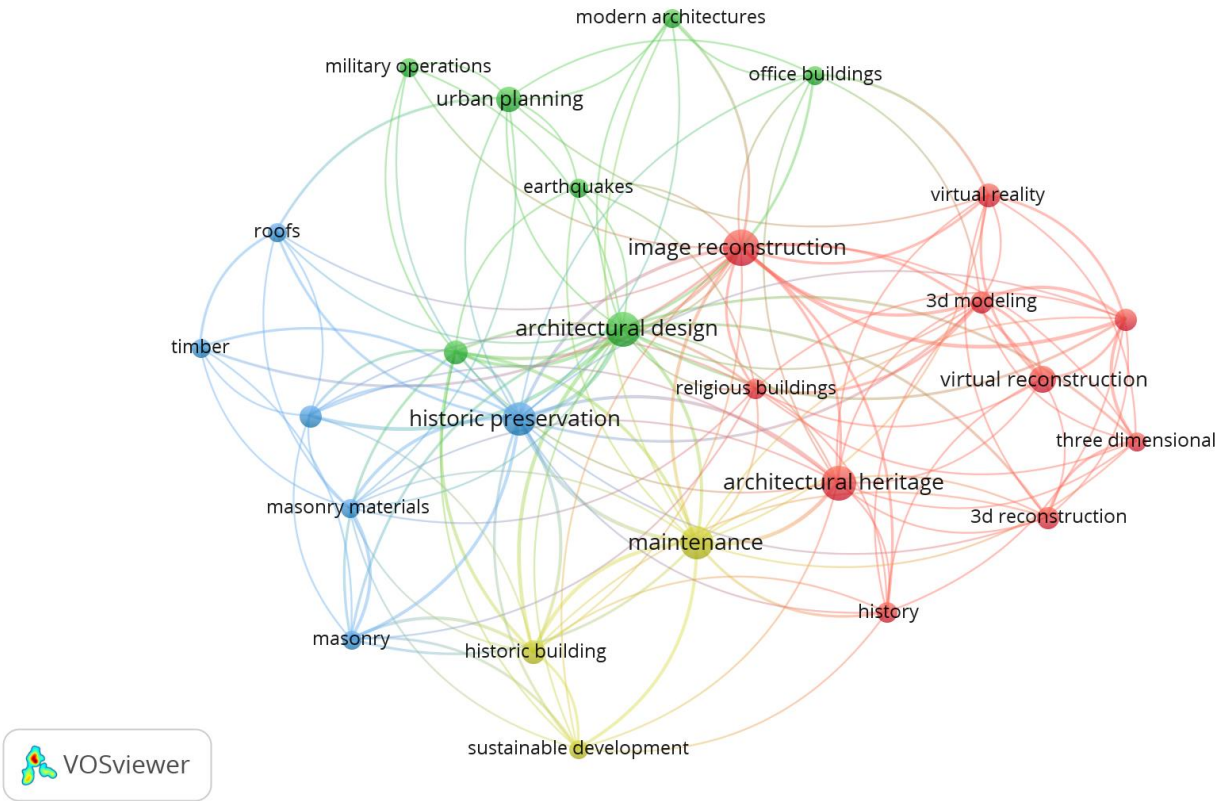

Figure 3. Graphic showing keyword clustering in historical building reconstruction research.

C. *Research Opportunities on Historical Building Reconstruction*

Based on the results of the bibliometric analysis, several research opportunities can be proposed regarding the reconstruction of historical buildings. First, the recent trend shows that research on this topic has led to the reconstruction of historical buildings made of brick and their preservation efforts using 3D reconstruction. Second, the focus of research on the reconstruction of historical buildings, which is still discussed to a limited degree in international journals, is related to the reconstruction of historic buildings with a focus on urban planning, including office buildings and buildings made of brick, where this preservation effort is carried out through virtual reconstruction. Third, the reconstruction of historical buildings is very likely to be carried out in Spain and France, considering that the amount of research contributions there is still limited compared to the number of historical sites in these two countries.

IV. Conclusion

This study aims to provide an overview of research that has high impact in the field of reconstruction of historical buildings. By using the VOSviewer application, researchers can ascertain the bibliometrics of these studies and the opportunities for future researchers related to this topic. Based on the results of the bibliometric analysis, several research opportunities can be proposed regarding the reconstruction of historical buildings. Research trends within this topic tend to lead to the reconstruction of historical buildings made of wood by using virtual reconstruction as an effort to preserve their existence. In view of the number of historical sites in Spain and France, research on historical buildings in those countries is still very limited.

This study was conducted by collecting data about articles provided by the Scopus database. Of course, this is a limitation of this study. A lot of research on the reconstruction of historical buildings has been carried out and then published in journals that are not indexed by Scopus. For example, journals indexed on the Web of Science and Google Scholar. Limited access to the Web of Science has resulted in this research not using this database to retrieve article data. Google of Scholar was not used in this study due to the incompleteness of the abstract metadata provided by the database. Future studies may consider incorporating articles from other good quality databases so that the results of the bibliometric analysis will be more complete.

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