

Bibliometric study on the interest growth regarding 3D concrete printing for Civil Engineering

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ABSTRACT: *On the history of Civil Engineering there's been an improvement on the search for developing and implementation of cost reduction innovative techniques, raising the productivity and lessening Environment damages, that interest has a fast growth according to time and has become even more imperative on modern constructions. Those methods are based on the shortening between the concept project and the execution, eliminating unnecessary projects, wastage thus raising the reliability and safety. On of those techniques, which reaches all the desired benefits and has been calling huge interest is the 3D Printing on the building process, this technique is already on advanced stages in countries as Holland, although in Brazil is still a subject under initial research. Based on that information, through a bibliometrics study this article gathers the up growing number of publications on such topic and also the researchers with greater efforts on developing the subject through publications.*

KEYWORDS: *Construction, 3D Printing, Concrete.*

I. INTRODUCTION

On a modern world the search for low cost and more efficient solutions (TOST e WU, 2002). Florêncio et al (2017) and Taparello (2016) highlight that in the last 10 years revolutionary technologies have shown up and made possible to turn an office-based environment such as prototypes into real scale objects with a high-fidelity execution. It's a new era on the matters of Architecture, constructions, construction sites and Civil Engineering. According to Florêncio et al (2016) analyses, it's a shortening between the stages of the concept project, both basic and final; and the buildings originated from them. This new knowledge area definitely brings Civil Engineering to the digital era in which is possible the complete housing building process with 3D concrete printing technology. Inevitably the Civil Engineering workforce will have to specialize themselves even more in order to use new technologies and obviously it will contribute to new job posts hence the 3D printing completely changes the way to work and produce. Throughout a bibliometric study in order to come up with a deep understanding on the scientific production field, through articles and researchers' studies to gather data regarded to the present theme, using the words, by themselves or concomitant, related to this article topic. Thus, identifying the quantity of publications by year and researchers who shows a greater interest regarding all the others.

II. METHODOLOGY

Bibliometry: The term Bibliometry was created in 1960 by Pritchard, according to Pritchard himself in 1969 he also created the concept of statistical and mathematical study of publications. Such study first showed up on the publisher Hulme (1923) and the intellectual Lotka (1926) which believed that the way to get deep knowledge about any subject would be through academic journals. (Lundeberg, 2006) Bibliometry study is the search for previous publications and studies over the desired topic, locate the institutions and researcher which have already published on the related subject and also what was the reason on them to doing so. This is made possible by using filters capable to relate to the citation indices created for that merit. (Okubo, 1997) The strictness on the study is determined by the Three Laws the guides this method, which are shown on the chart 1 below.

Chart 1: The Three Bibliometric Laws

Laws	Measurement	Criteria	Main Goal
Bradford’s Law	Scatter of the articles over journals in given subject	Journal reputation	Identify the most relevant journals and with a vast approach to the topic in matter
Zipf’s Law	Keyword frequency	Theme order list	Determine the most common topics related to the field of knowledge
Lotka’s Law	Author’s productivity	Size – frequency	Analyze the impact of an author on a field of knowledge

Source: Chueke, Vouga Gabriel; Amatucci, Marcos (2015).

III. RESEARCH METHOD

The undergoing research, according to Severino (2017) is basic nature for it analyzes the existing academic journals on the topic considering some aspects such as: relevant authors over the last years, also the increasing on journals per year which takes place the present bibliometric study. According to the research goals it can be classified as investigative due to its intention on mapping the topic based on data from the Scopus platform with combine approach: qualitative and quantitative. As for the method applied it’s a bibliometric study.

Research Planning : The research started by identifying the search platforms capable to gather several publications around the world regarding 3D concrete printing. Following that it was set keywords to start an organized scanning over the theme. Using Scopus database the research was initially set to identify predominantly the terminology *Concrete 3D* as the database in use has a broader range of results on the English language.

The research planning at this period was focused on indentifying the following data:

- Number of publications related to the theme from 1958 to 2018;
- Most relevant authors who have already published on the topic;
- Once these aspects have been discussed, the word Construction was tagged to Concrete 3D which caused a narrowing on the bibliometric study leading to the results to reach goals of the present study.
- Following the same pattern applied previously now on a much smaller sampling field.

IV. RESULTS AND DISCUSSIONS

Bibliometric Study regarding the terminology “Concrete 3D” : Image 1 shows the improvement on the number of publications with the terminology “concrete 3D” in the world. There’s an increasing interest on the topic with an exponential increase in the beginning of the 21st century. It’s key to point out that the research covered the years from 1958 to 2018. Being the year 2017 the one with the largest number of publications 645, followed by 2018 with 575 and 2016 with 527 publications. It’s noticed an up growing interest increase over the years.

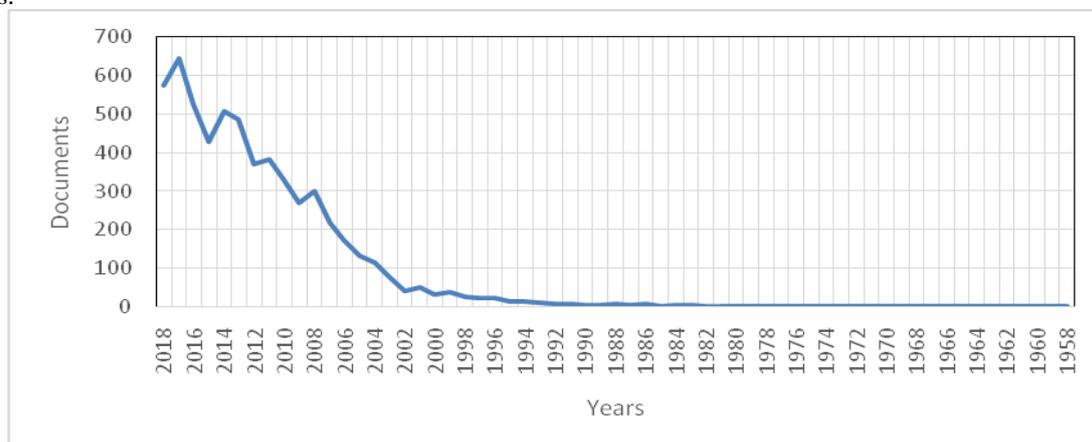


Image1: Documents per year.
Source: Scopus (2018)

Image 2 shows the most relevant authors who have published on this topic. Joško Ožbolt graduated on the University of Zagreb in Croatia and the University of stuttgart in Germany is the author with more publications, with a significant advantage on the research due to 42 journals on the topic. The second is Varma with 24 and Papadrakakis with 28 documentations.

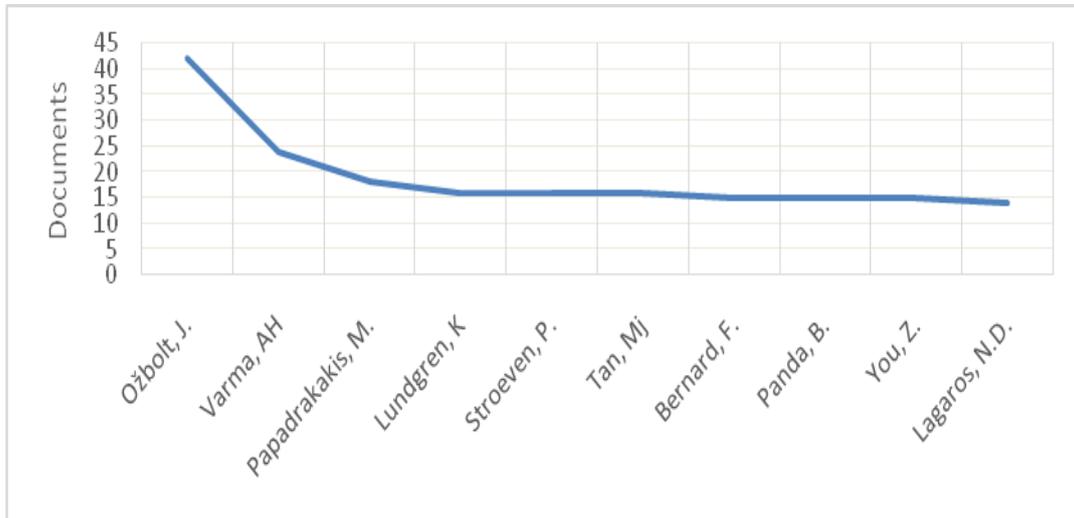


Image 2: Documents per author.
Source: Scopus (2018)

Bibliometric study considering the terminology “Concrete 3D” tagged with the terminology “Construction”: After a research for journals based on the two terminologies together from the previous 5,820 documents, 1,653 also contains the second terminology. It’s important to point out that by combining the two words the starting years now is 1978, changing the research gap year from 1978 to 2018. The year 2018 which showed the largest quantity of publications, keeping the tendency to the interest growth, as shown on image 3.

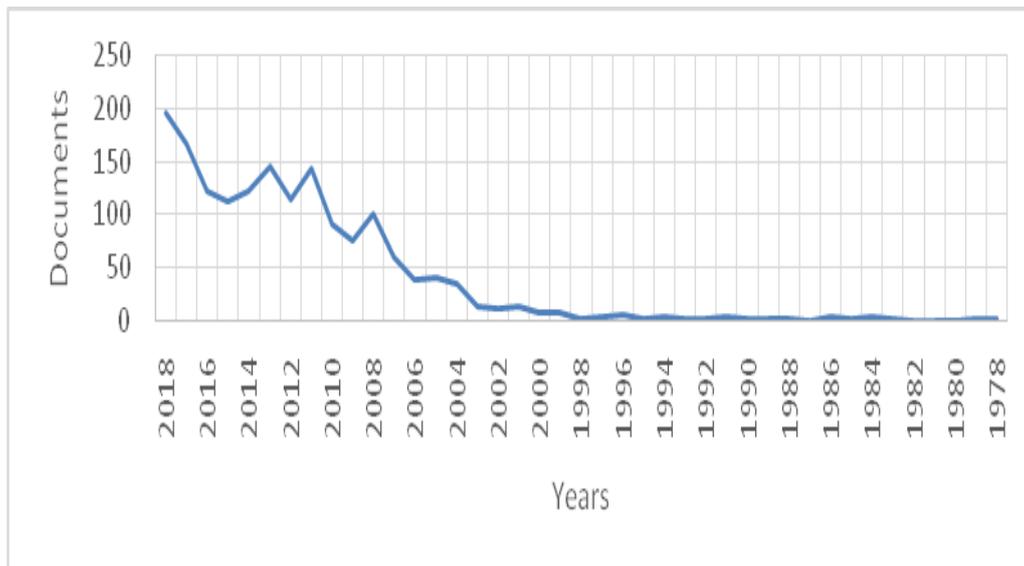


Image 3: Documents per year.
Source: Scopus (2018)

Image 4 shows the ten authors with the largest number of publications over “Concrete 3D” and “Construction”. Ožbolt even after the combination of both terms still has more publications on both subjects, 15 documents.

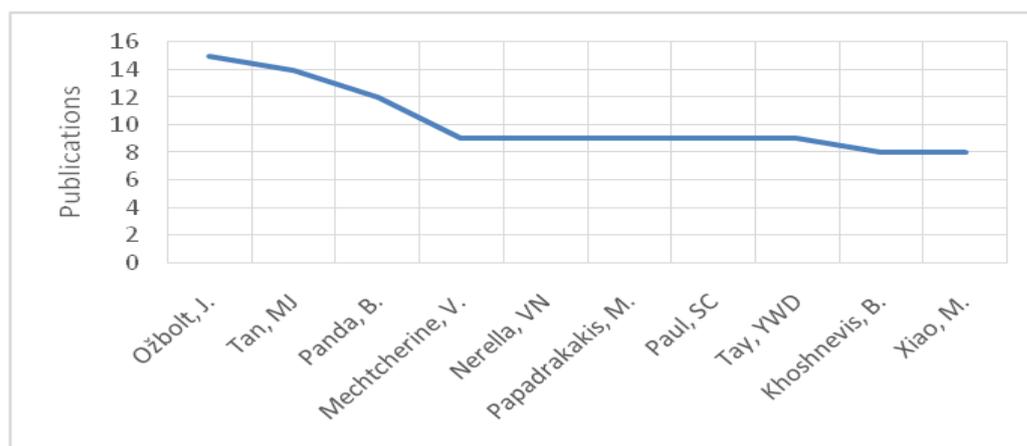


Image 4: Documents per author.
Source: Scopus (2018)

IV. CONCLUSION

Based on the research and graphic results gathered it came to the conclusion that the interest over the observed theme has been increasing, both by the scientific-academic community and the application by companies even that there isn't relevant number the growth is due to the fact that the project has been improving even more and by the benefits provided by it. In more developed countries such as China and The United States, 3D printing on the Housing Building field is already a reality. Regarding Brazil, the researches show that the theme such as the keywords cross reference used on the research can't be taken as important and representative research material. Some publications are yet identified, however, when compared to a worldwide base, they are seen as non-significant values. Such results lead to the necessity to Engineering improvements on the related technology studies and research with the intention to develop a better suitable way to apply it to each country or region. Furthermore, advancing on the researches about the studied topic will certainly help on cost reduction on projects and constructions and also accelerating the process of expanding the technology application.

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