

Original Reserch Paper

Explanation of Fundamental indicators in digital architecture achievement

Mohamad Reza Akbarian, Mahdis Koolivand Saluki, Mina Zerang*

Department of Urban Planning ,Faculty of Architecture and Urban Planning, Soore University, Tehran, Iran

Received 18 Apr 2021

revised 30 Jul 2021

accepted 30 Aug 2021

available online 15 Feb 2021

Abstract: Considering the increasing growth of construction in the country, it is important to pay attention to the architectural aspects of these structures. Progress in The field of technology and the need to build new structures requires advanced tools for designing instrument models. One of the ways of designing new instrument models is digital architecture. Digital is a mechanized media with unlimited capabilities that have also affected art in the process of the world's progress towards digital culture. Digital architecture is a movement in the field of architecture to provide a basis for more creativity and innovation with the connection between architecture and digital science. In the digital space, the architect is freed from the limitations of designing the architectural space with common methods and the slowness of working with previous drawing tools in the current era, and the details are imagined. Depicts a design in advance. This research seeks to reach the criteria of digital architecture by using integrated research method (quantitative and qualitative) and based on library studies and questionnaire results. So that with their help, an effective model can be provided for the analysis of every building with digital architectural components. Based on this possibility It should be ensured that by introducing the characteristics of any desired building, the amount of attention paid to digital architecture in that building can be investigated gave.


Keywords: Digital architecture, building analysis, digital science, creation and innovation

RUNNING TITLE: Fundamental indicators in digital architecture achievement

INTRODUCTION

Architecture in the word is the birth of a thought in the area of a specific goal, which if following a defined path to the observer It allows to clearly see the stages of the birth of thought until its visualization. For the architect's ability in industrial design and production and the possibility the visualization of unconventional architectural forms should be provided to the architect as a tool to create space and also to produce new and advanced structures. It should be noted that this tool is made possible by the use of technology and complex graphics facilities in the computer called digital architecture. (NBS, 2007) Today, digital technologies have affected many as-

pects of our lives and its application in world architecture. The advent of computers and the advancement of technology has completely transformed human life such that it is not possible to live without the use of technology. Using computers in engineering sciences and so on Especially architecture has created a huge transformation and different categories of digital skills and new examples of architectural knowledge has created Digital architecture should create a suitable environment for information exchange by using images, lightings and visualizations provide knowledge It helps users to benefit from interactions. Digital architecture gives this possibility to the designer. To be able to perform processing on the computer at a very high speed and with a very high memory volume in the way of designing and creating three next, it deals with architectural

 *Corresponding Author Email: koolivandsaluki.m@gmail.com tel, +989033391165

spaces and evaluation and comparison of different options (Moqtadinejad and Pashaei, 2015). Therefore, we need a completely new communication environment with a special architecture to be able to organize this large amount of communication in today's era, digital science and architecture have a wide connection with each other. Especially in recent decades of link architecture, It has become inseparable with computers and scientific developments in this field. For almost 50 years now, software Various capabilities have been provided to architects, both in the field of presentation and in the field of modeling, and therefore every day We are witnessing a wider penetration of computers into architectural offices (Golabchi et al., 2013). Digital architecture is a new perspective for the design of cities and buildings is considered, and it can be called as a revolution in the world of architecture, which promotes the process of the design has been implemented. This research is designed to answer the following question: How can you reach the criteria of digital architecture by knowing the parameters of digital architecture? The general goal of this research is to provide an efficient model for the analysis of any building in the field of digital architecture. Actually, looking to achieve the criteria for reaching digital architecture is to provide a final model for the analysis of each building with digital architecture components. That in Finally, it gives the possibility to the user to introduce the features of any desired building to be able to pay attention to the digital architecture in that building examine.

Literature Review

Early 19th century, with the replacement of coded information with direct control, one of the different cases of digital culture came to the fore appeared Most historians believe that with the emergence of information-based society in the 19th and 20th centuries, digital culture came to work; A culture that many technology experts have called the second industrial revolution (Mulanai et al., 2015) The world of digital analysis came to the aid of architectural design almost from the 1960s. At that time, projects Like the Sydney Opera House, they were in the design stage to model and plan how to imple-

ment it, without using the facilities computers were practically not possible. Gradually and with the entry of more of these facilities and technologies into architecture, architectural design as well underwent a change and the forms progressed towards volumes that had almost no restrictions on their production (Globchi and et al., 2013) In the design competition, with a design in which skins and curved instruments are designed as stable arches. He had won, and from the very beginning, he was raising many questions about his plan in his mind. This complex design, designers and who were implementing the project, thought of a way to implement the project. This project is the same house of Ove Arup accountants company It was the Sydney Opera House that provided the leading software in the field of computer-aided design. This digital model is easy to use Wetting the structural analysis of the building, to deal with the details of the parts that were supposed to be connected to each other to prepare the model If it is placed in the construction phase of the building, it will provide a measure of action. In this way, all the important components of the building, including Steel structure system, glass parts, parts covering grooved surfaces, shells and prefabricated parts of the roof with complete details Modeled. Digital architecture is the practice of using digital technology to link design and construction in architectural projects The use of digital tools expands the designer's intelligence and makes architecture as a science that should be experimentally researched If it takes place, it will be paid. Digital architecture deliberately has diverse approaches and does not introduce any specific architectural movement does not. (Volk et al., 2014)

The concept of digital architecture

Throughout its history, architecture has always presented manifestations of different social attitudes of the society. Always one There has been an unbreakable and strong link between architecture and social developments. Many changes also in the architecture as a result of the changes social has occurred. Today, as the era of computers and the Internet, significant changes have been made in the evolution of architecture (Abbaszadeh, 2013). Today, technol-

ogy affects all aspects of human life, and architecture is no exception in this regard. Has not been. Day by day, new words are added to the vocabulary of architecture, and new technologies have deep and wonderful effects. We put on architectural components, maybe the emergence of digital culture in architecture is also a sign of this influence. (Picon, 2013) In architecture, we try to imagine the space first and then express what is going on in our mind. So, with a lot of volume, we are faced with a lot of data that we process and present using various methods. Architectural design usually in the written form is not done, but with different methods and techniques, we equate the designed space to it. Let's see and make decisions about it and finally turn it into real buildings. So, as a result, it should be said that this.) The process will be highly technological (Khabazi, 2012). Digital architecture is the use of computers for modeling, programming, simulating and imaging for creating virtual shapes that allow the designer to precisely control the stages of creation from thinking to visualization. In fact, Digital architecture is a movement in the field of architecture that, by combining architecture and digital science, provides a basis for more creation and innovation in the new era and in the digital space, the architect has gone beyond the limitations of designing with common methods and such defects. The slowness of working with the previous drawing tools is abandoned and he can depict more details of the desired design and make it. (Tamizi et al., 2015)

Digital architecture allows the designer to perform processing on the computer at a very high speed and with a large amount of memory very high in the way of design to create three-dimensional architectural spaces and evaluate and compare different options (Moqtadinejad and Pashayi, 2015) We need a new generation of architects to not only design buildings, but also, according to Plan for them. We need architects who, instead of cooperating with structural and mechanical engineers, work with computer engineers. Therefore, we work in a fully communicative environment (Oosterhuis, Digital designers. They are the new generation of architects (Oosterhuis, 2015). We need a new one with a special architecture to be able to organize this large amount of communica-

tion. Digital architecture despite a history in short, it has been able to grow significantly by relying on new technologies. This is similar to a revolution in scale is small, and its various aspects will be expressed in the near future. (Loumer, 2015)

The role of computer in digital architecture

In the new century, with the entry of computers into the field of architecture, new horizons have been opened for architects. (Picon, 2013) Computers, tools in fact is a powerful tool that can play a multimedia role in conveying an idea from the designer to the audience. It can be said that the issue of using computers in architecture is divided into two parts:

- 1- Enriching the design using the digital design environment;
- 2- Its implementation using digital facilities.

If these two parts are not in a single system, they lose their meaning. Therefore, it should be an all-round thinker

It is called the purpose of CAD/CAM is to regulate the relationship between these two parts. This comprehensive system is a digital design and manufacturing system. This is the system of designing and producing buildings using digital tools. Using these digital tools while reducing the possibility of the occurrence of human errors also provides designers with many possibilities. Basically, the central core of the design and production system) computer assistance consists of three main parts, which are: (Golabchi et al., 2011)

- Structural part of the building;
- Interior design department of the building;
- Department of facilities and mechanical systems of the building.

Architectural design tools, their importance and types

Architectural design is the most important knowledge and skill of an architect to express himself, mentalities and the thought is his. This expression is through light, texture, form, color, line, point and so on Surfaces (Khayaniyan, 2018) manifest by means of design tools. Cognition Architectural design tools and their place in the architectural design process need to be known. Its features and components. Design has a process that measures the result. It is. When de-

sign becomes a conscious act, knowledge, skill, follow-up, Persistence and design tools influence its process. Although the tool Designs are mostly used to explain a specific action or verb, in fact, They include features that are closely related to architectural design are located Because by using this tool, seeing thoughts, analyzing ideas, structures, etc. It becomes possible to present the plan. So, the images in the mind of the architect with the encounter It is created by the problem of design, as well as his imaginations and thoughts, in order to register and Long-term preservation requires design tools. Also, they have the possibility to subscribe They provide mental images and evaluations. (Ching and Juroszek, 2010) Express the designer well and correctly because these ideas and thoughts are used These tools become a reality and this plays an important role in architectural design And it is effective in realizing the designer's thoughts and ideas. Design tools with the power of objectifying thoughts help the designer in different stages of design and importance There are many in this direction. Designer tools should be able to develop the design process provide the data and qualities of the plan exactly and the possibility of checking, analyzing and evaluating it provide. (Lockhard, 1982) Computer software has been developing rapidly in recent years, and every year there are new editions with new features They offer more to the market. These software's, in addition to the basic design and drawing facilities, also provide facilities to control the design have provided such as: shape and form control parameters, material parameters, light sensitivity, size parameters, parameters Computational and structural and the like. Today, these powerful software's allow the control of stresses and loads on the building, calculation They have also provided light and shadow, heat, internal ventilation, etc. For their users so that the designer can have more control in the space as a tool (digital CAD) on your proposed design (Khabazi, 2012). Some computer-aided design It is considered unimaginable for engineering work. Architecture by bringing parametric controls] in the following additional explanations about the parametric topic will be presented [in the space of digital design along with software upgrades in the production of complex forms It became new. The designer can

use software based on programming and coding to produce very complex forms. Pay more in this way, 3D software that in the past was only available through the creation of individual volumes and forms It was possible to edit them using the commands in the user interface of the program, nowadays new software's allow parametric development Based on the algorithms in the program, they have provided their users with a new digital revolution in the field) form the design. Architectural design software is divided into several categories. (Khabazi, 2012)

Drawing software:

This category of software has many tools for 2D and 3D drawings in their environment. Software like AutoCAD, Sketchup, Rhino and 3D Max.

- Parametric software:

There are softwares that produce parametric forms either independently or by installing a plugin on it they do. One of the most important of them is the Grass Hopper plugin, which is installed on the Rhino software and has powerful features.

He uses Rhino for his drawings.

- Computing software:

These softwares are responsible for the calculation tasks of the project. Such as structure and energy calculation software.

- Parametric-drawing software

These softwares have an intermediate parametric and drawing mode. Such as Visibility software, which, in addition to modeling forms, It defines parameters on it and takes it out of the state of past and traditional drawings and into the category of professional drawings brings closer Computer-aided production is the use of computer software to control related tools and machines in the production process It is said that the user describes how to convert CAM, in short, to any automated manufacturing process that is controlled by a computer The digital model deals with the instructions of the machine. An integrated role between the thoughts of designers, technical consultants, provided by an online database and software agents, all inputs to produce a digital model / physical model. The output of these models is mapped, images, animations, analytical reports and so on are CAD/CAM manufacturing components made by facilities. (Mitchell, 1995) (Fig.1)

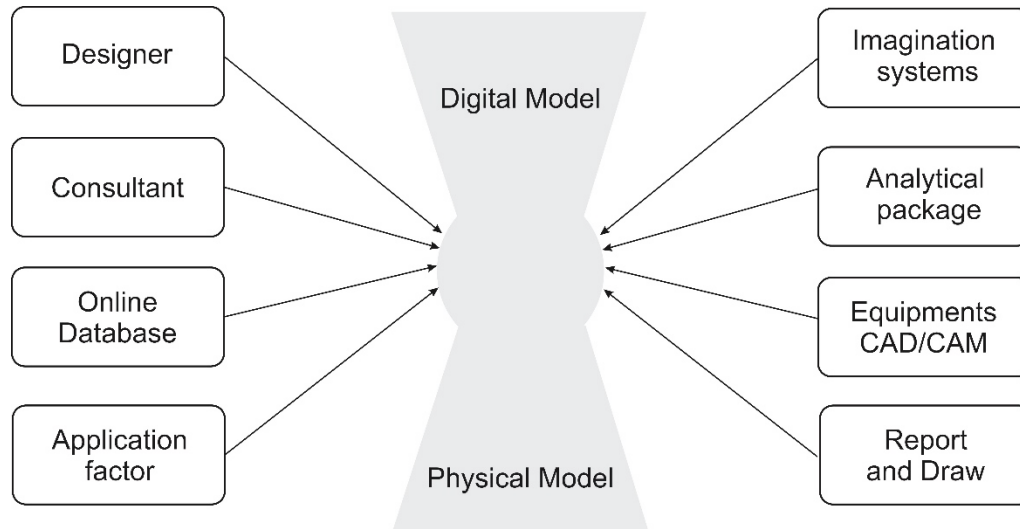


Figure 1: Integrated roles towards a digital model

And its editing, this design with a volume generator machine based on digital data (CAD) after computer-aided design in material form, the use of a 3D printer (CAD) will be completed to make a 3D model designed on a computer needed. This process is considered the beginning of digital fabrication at the design level. Digital model information data produces Next, it is translated to CNC equipment and CAM numerical control instructions by production software (Elghaffar, 2007) Manufacturing is transferred like a 3D printer, 3D printing construction is a new technology that offers new performance capabilities, although conditions Its construction has not yet been specified in detail. 3D printed structures, the capacity of automated technologies to build buildings They express through additive construction. These structures need architectural design according to their construction conditions. The first rapid hardening concrete layer system is proposed in DPC references to 3D printed construction. It was suggested that the freedom of form by this remarkable technology Rensselaer 1997 by Joseph Pegna 1 of the Polytechnic Institute at the University of Southern California and subsequently, the concrete printing system was B. Khosnevis. Later in 2002, the contouring process by developed in 2005 to create large pieces such as a 2008 Loughborough sculpture at the University In recent years, a large number of then used as part of a house and a small integrat-

ed cabin Companies in Asia, Europe, and the United States have made public 12 examples of 3D printed buildings, 2 (in the search conducted by the end of January. (Buswell, 2020) It was identified as including photos and a statement of their 3D printing process.

Advantage and disadvantages of using 3D printers

Among the advantages of 3D printers, the following can be mentioned:

- 3D printing gives architects the opportunity to be completely flexible in designing their desired buildings.
- By using 3D printing, construction costs are much higher both in the overall construction and in the parts of the building coming down.
- The house designed by the 3D printer will show better and more accurate results. Because the design file directly from the computer is transferred to the machine and human error does not play a role in it.
- The use of 3D technology can reduce construction waste by 30%. Among the disadvantages of using 3D printers, the following can be mentioned:
- In 3D printing, only concrete and plastic can be used to build structures, and buildings that are divided into components such as steel and wood require, cannot be made with this technology.

- Currently, there is no law in our country to approve buildings built with 3D printers. Few people are aware of this technology and have the necessary skills to implement it.
- This work causes the reduction of manpower in the construction stages, which eventually leaves many workers unemployed.

Algorithmic design

Algorithmic architecture has been active in both form-spatial creativity and technological innovations since its inception has done. Principles and features such as the use of soft and fluid surfaces, breaking these surfaces into similar but not identical parts, The gradual changes of forms and parts, the adaptability and responsiveness of the architecture and its components to the internal and external conditions of the project, etc. The main slogans of formal-spatial behaviors are algorithmic architecture. However, the desire to use advanced technologies Design and construction in the field of algorithmic design have provided new fields of innovation (Khabazi, 2012). Patrick Schumacher believes that in today’s world,

there are acceptable and successful designs that use technologies and tools in their design. The design of a single technological system should be used. He speaks about parametric and algorithmic architecture layer and applying design edits to it, moving towards a multi-layer design and at the same time coherent and continuous subsystems did Applying any design operation on a subsystem must be related to the rest of the system components and have an effect on them as well (Schumacher, 2009). Some algorithms in digital design. (Tab. 1)

Parametric design

In this method of design, unlike the old methods, it takes a lot of time to change the design and add details to the design Less is required and there is no need to redraw the design to apply changes. In fact, you can make changes in one Part of the plan applies changes to all parts of the plan. Variables in parametric design are interdependent and this Variables are obtained by parametric equations (Tajvidi, 2018).

Table 1: A number of commonly used algorithms in architecture are introduced.

Algorithms	Description
Random variables	Sometimes in the algorithms, depending on the desired design, random variables can be added to the production process in such a way that entering a random value will affect the entire network.
Random search algorithms	Unlike the algorithm that was mentioned above and a random variable had an effect on the entire network, in This algorithm has existing rules and laws, and the algorithm is constantly looking for answers that we We have specified it. Random search means searching in an environment full of data and Search for a combination until the specified condition is met.
Voronoi algorithm	Voronoi is a random pattern and a bimetic pattern (biomimicry) that is the result of formation It is a structure with the least materials and the least energy in nature.
Attractive algorithms	This algorithm follows random patterns. In such a way that the points as absorption points is defined and the network changes shape based on these points.
Automatic cellular machines	A cellular automaton is a discrete model consisting of a regular and finite network of cells is that each of them can assume a finite number of states.

Parametric design is basically based on algorithms. are that providing the possibility to express parameters and rules that together define, code and modify the relationship between design intent and response. (Labi, 2013) The origin of the term parametric is from mathematics, in fact it refers to a system that can be expressed by changed its parameters and edited or changed its equation with the aim of improving the result. (Frazer, 2016)

- Types of parametric design systems:

Parametric design systems can be divided into two general types:

- 1- Systems that are based on diffusion, which consist of a computer and a data flow model.
- 2-constraint systems that solve discrete and continuous constraints

FINDINGS AND DISCUSSION

According to the collected materials as well as the examination of the presented case examples, the criteria for achieving architecture can be determined Summarized the digital. This summary will be presented in Table 3. In this table, there is a column called points has been In this section, each of the proposed criteria and recommendations is rated according to their importance in digital architecture (between 5 and 20 points) and at the end, with the help of the results of the questionnaire, it is determined that in the case samples presented up to How much digital architecture criteria are used. (Tab. 2)

RESULTS AND CONCLUSION

The response of architecture to the needs of today's users has led to the emergence of new methods in architecture. In this method- computer is used as a design tool, which causes the formation of spaces with non-Euclidean geometries and it's complicated. Digital architecture is one of the new branches of architectural knowledge that causes the emergence of categories There are different approaches to digital architecture and, accordingly, digital skills. In the research question, we want to understand: "How can we reach the criteria by knowing the parameters of digital architec-

ture "Digital Architecture Achieved?" And the purpose of conducting this research is to "provide an efficient model for the analysis of every building in the field of digital architecture" which ultimately to give the user the possibility to find out the location of the desired building in the field of digital architecture. In order to achieve this goal, one should first understand the important types, features and characteristics of digital architecture in this regard, the necessary materials were presented in the "theoretical framework of the research" section. In the following, it was tried to examine and analyze the characteristics of used in the case examples to achieve a summary of the characteristics of digital architecture. With the help of this the features can be used to reach the criteria of digital architecture and according to their importance in digital architecture Scored to determine at the end how much digital architecture criteria are presented in the case examples Used. The increasing use of computers in the fields of design, architecture and engineering is one of the most important achievements of recent years It is considered to improve the design process and increase productivity in different stages from design to implementation of a project. Design process and Computer-assisted production can be used in a wide range of scientific and industrial activities today, such as architecture, industrial design, Construction engineering and mechanical and industrial engineering play a very important role. Digital architecture for designers and architects the creation of real structures helps in the virtual form as they can before building the design in the interior space Examine all the conditions of the plan. The final goal in the process of digital architecture is to build a four-dimensional model, including all the information needed for design and production Digital manufacturing and timing information is necessary for its assembly. This source of project information enables architects Take the role of information coordinator between all professions and industries involved in construction. The findings show that digital architecture has created new opportunities

Table 2: A number of commonly used algorithms in architecture are introduced.

Category	Criteria	Description	Score
Spatial quality in terms of Display volume	Form finding using design techniques Digital and related software	such as: geometric interpolation, random processes, Chain transformations, fractals, gain Derivation of mathematical operators on volume	20
	The use of robots in construction	(Canadarm), such as: articulated robots, Cartesian robots with the ability of 3D printing, (collaborative robots), assistant robots and...	20
	Construction and production of building components in the environment digital	Building shell like human skin vs Cold, heat, humidity and other climate changes react	10
	Envelope skin	Using small components similar but not identical Completely identical. Curved and fluid surfaces and volumes, they are divided into these components and these components are possible Provides complex constructions.	15
	Component based design	The use of different algorithms in building design and adherence to the principles of parametric architecture	20
	Using parametric and algorithmic architecture in different parts of the building	Form and structure are designed parallel to each other	5
	Emergence of form based on the structure of the structure	The use of soft and fluid lines in the parts different buildings	15
	Use of fluid, non-linear and transformative movements built	Creating repetitive patterns One of the characteristics of parametric architecture.	20
	Texture mapping-Patterning	Such as: materials with the ability to change properties, and (PCM) phase change materials) materials Materials with movement properties.	20
	Smart Materials		
	Stability based on the climate of the region using soft Related applications and plugins	Various plugins for radiation and energy analysis The building has been supplied to the architects It helps to have a more stable design. Ladybug and Diva like plugins	20
	Interaction between the shell and the surrounding environment	Greater connection between the building and the site	5

in the field of building advanced structures. However, today there is no single digital design environment that can handle all the design needs and estimates needed for fulfill the implementation, therefore, the separation of new software in terms of their participation in various building departments and specialized fields each one is inevitable.

REFERENCES

- Afify, H. M., & Elghaffar, Z. A. A. (2007). Advanced digital manufacturing techniques (Cam) in architecture authors. In Proceedings of the 3rd International ASCAAD Conference.
- Andadari, T. S., Purwanto, L. M. F., Satwiko, P., & Sanjaya, R. (2021). Study Of Digital Architecture Technology: Theory and Development. *Journal of Architectural Research and Education*, 3(1), 14-21.
- Buswell, R. A., da Silva, W. L., Bos, F. P., Schipper, H. R., Lowke, D., Hack, N., ... & Roussel, N. (2020). A process classification framework for defining and describing Digital Fabrication with Concrete. *Cement and Concrete Research*, 134, 106068.
- Frazer, J. (2016). Parametric computation: history and future. *Architectural Design*, 86(2), 18-23.
- García-Alvarado, R., Moroni-Orellana, G., & Banda-Pérez, P. (2021). Architectural evaluation of 3D-printed buildings. *Buildings*, 11(6), 254.
- Gürsel Dino, I. (2012). Creative design exploration by parametric generative systems in architecture.
- Hosni, Mahsa. (2016) Investigating the impact of parametric design as a processing tool in architecture and structure, the third annual research conference of architecture, urban planning and urban management, Shiraz
- Issa, Y. B., Mojahid, M., Oriola, B., & Vigouroux, N. (2009, July). Accessibility for the blind: An automated audio/tactile description of pictures in digital documents. In 2009 International Conference on Advances in Computational Tools for Engineering Applications (pp. 591-594). IEEE.
- Jabi, W. (2013). Rigorous creativity through the integration of parametric design, performance analysis and digital fabrication.
- Khabazi, Zovin (2012) *Algorithmic Architecture Paradigm*, 2nd edition, Kasari Library Publications, Mashhad
- LouMer, S. H. (2015). Digital architecture and intelligent buildings: A suitable approach to proper implementation of sustainable development components in the third millennium. *Curr. World Environ*, 10, 74- 81.
- Mitchell, W. J., & McCullough, M. (1995). *Digital design media*. John Wiley & Sons.
- Molanayi, Salahuddin and Molanayi, Sina (2015) "Digital architecture, parametric design, the emergence of new literature in architecture and inevitable style". The first national conference of technology in applied engineering of young researchers and elites club of Islamic Azad University.
- Moqtadinejad, Mehdi and Pashaei, Souda (2015): Investigating the impact of the parametric architecture design process based on the algorithmic design of a new method in Designing digital architecture in line with the goals of sustainable architecture, the third international conference on modern researches in civil engineering, architecture, Urbanization, Berlin, Germany.
- Muhsin, A., & Rahadian, E. Y. (2022). CAD, BIM, Parametric and Their Use as Auxiliary Tools in Design Studios. In *International Webinar on Digital Architecture 2021 (IWEDA 2021)* (pp. 89-92). Atlantis Press.
- Picon, A. (2013). Substance and structure II: The digital culture of landscape architecture. *Harvard Design Magazine*, 36, 124-129.
- Poulsgaard, K. S., & Malafouris, L. (2017). Models, mathematics and materials in digital architecture. In *Cognition beyond the brain* (pp. 283-304). Springer, Cham.
- Schumacher, Patrik. (2009). Parametricism – A new global style for architecture and urban design, *AD – digital cities*. vol 79, No.4.
- Tajvidi, Mohammad Amin (2018), The process of parametric design in tall buildings. *Architecture and Culture*, No. 36
- Tamizhi, Manouchehr-Nazari Pourgol Sefidi, Leila-Shabani, Roya (2015) The role of digital science in architectural design, the third international conference Research in Science and Technology, Berlin, Germany
- NIBS, National Building Information Modeling Standard (2007), Version 1- Part 1: Overview, Principles, and Methodologies, National Institute for Building Sciences (NIBS), Washington, DC, USA, December.
- Volk, R., Stengel, J., and Schultmann, F., "Building Information Modeling (BIM) for existing buildings Literature review and future needs," *Automation in Construction*, vol. 38, pp. 109-127.
- Lockard, W. K. (1982). *Design Drawing*. Revised Edition. Van Nostrand Reinhold Co.: New York.
- Ching, F. D.K., & Juroszek, S. P. (2010). *Design Drawing*. (2nd Edition). John Wiley & Sons, Inc.: New Jersey.