



MECHANISMS OF FUNCTIONAL GROWING IN THE VALUABLE BUILDINGS

Saif K. Aljashaami¹ and Ali M. Alkhafaji²

¹ Researcher, Department of Construction and Projects, University of Kufa, Najaf, Iraq.
Email: eng.saif.82@gmail.com

² Professor, Architectural Department, University of Technology, Baghdad, Iraq. Email:
alimkhafaji@yahoo.com

[HTTP://DX.DOI.ORG/10.30572/2018/KJE/120204](http://dx.doi.org/10.30572/2018/KJE/120204)

ABSTRACT

The processes of changing architecture became necessary with the change of the basic needs and requirements of society, and in order for the architecture to survive, it must possess the necessary characteristics in achieving this (living architecture). Simulating the basic principles of living organisms in nature (such as growth) plays a major role in achieving this continuity. The importance of this process lies in the valuable buildings for their importance in society. Many studies addressed the conservation, reuse, rehabilitation, and did not address how they grow after making the appropriate changes to the future need, by taking advantage of nature. Therefore, the research problem lies with "the cognitive need to clarify the mechanisms of functional growing in the valuable buildings " and the research aimed to "explore the mechanisms of functional growing in the valuable buildings and their role in the permanence of those buildings." The first steps to solve this problem were to build a theoretical framework that includes those mechanisms and contains a set of variables to be applied to a group of selected projects in order to reach results and conclusions.

KEYWORDS

Growth, Valuable building, Living architecture, Addition, Morphogenesis, Renewal, Adaptation.

1. INTRODUCTION

Growth is one of the main characteristics associated with the organism, and it is one of the development concepts that is important to achieve in order to meet the new or changing needs of the organism to continue to live, adapt and interact with the surrounding environment. If architecture can be considered as an organism which can affect and be affected by the environment, then it necessarily needs to interact and adapt and therefore develop to meet the changing needs of society. Therefore, it is possible to know in detail about the most important mechanisms which would achieve the functional growing process specifically with valuable buildings for the historical and cultural importance of their presence and to maintain their original function or the new function that was transferred to (such as museums), and what is the role of growth in living organisms in achieving this. Assuming that simulating nature at all levels, such as principles, form, and behavior, enhances the achievement of the goal of functional continuity through its ability to change over time for its features of formal flexibility, adaptation, and response to the influencing conditions. To achieve this, it is necessary to firstly identify the linguistic and terminological definition of growth and growing, and their relevance to architecture. And secondly, get acquainted with the valuable buildings and their types. The research was conducted through four main parts:

First: Conducting a theoretical study of a set of scientific researches and books related to the concept of growth in living organisms and their relevance to architecture by identifying the most important principles of living organisms that can be used in architecture and how to achieve functional growing as a result of changes taking place to the basic requirements of society. Second: identifying valuable buildings, their types and the basic methods to deal with them as needed, then addressing the most important mechanisms that will achieve functional growing for this type of building. Third: Building a holistic theoretical framework through scientific knowledge presented in relation to mechanisms of functional growing, and choosing samples of selected museum projects according to the following three categories: (valuable buildings designed for a non-museum function, valuable buildings which have grown into museums depending on the adaptation mechanism, and valuable buildings which were designed as museums). Fourth: Applying the theoretical framework variables to the selected samples, then presenting the results related to the mechanisms of functional growing and conclusions.

2. FIRST PART: GROWTH AND ARCHITECTURE

2.1. The Linguistic Definition of Growth:

It is possible to identify the linguistic definition of growth by referring to the definitions found in the Arabic and English dictionaries and other sciences. The infinitive of the word (growth) is growing, which means to increase. In Lisan Al- Arab (Arab Tongue) dictionary by Ibn Manzoor, (growth) is defined as (grow in the sense of increasing and growing something means made it grown). In Al – Waseet dictionary, grow stands for increase, and the word (growth) in the Oxford Dictionary came to mean the process of increasing or developing in size, body, mind, spirit, economic, and value. In Biology, the concept came in the sense of an increase in the size of the body, to which a natural proportion join. As for Psychology, it refers to a steady change in the organism that is directed towards full maturity. While in economics, it was

associated with economic growth, which means a qualitative increase in per capita income or national or domestic gross product.

As for the linguistic definition of growing, it was mentioned in Al- Maany dictionary as: grow, grew, grown, growing, e.g. the plants are grown, meaning plants increased, and growing a news to someone means being informed. In the Contemporary Arabic Dictionary, the word was mentioned as: plants are grown, meaning plants grow gradually. In biology, it came to mean growing together, such as the fusion of parts, tissues, or cells related to each other (Shady, 2020). The word (growing) in the English language refers to increasing, mounting, rising, cultivating, becoming larger and ripe. As for biology, it was defined as the study of the relation between the shape and size of the body, and it is measured according to the different growth rates of the body parts of the organism as well as measuring the variation in shape between individuals according to gender and age, by using the comparison method according to the evolution and development. In economics, it reflects the increase in capital, and in sociology means an increase in the population (Abbas and Abdel-Zahra, 2014).

2.2. The Terminological Definition of Growth

Psychologists unanimously agree that their field of interest (growth) means (the set of changes that occur to the individual as a result of his aging), growth may not be an increase or a decrease, but rather a change in quality as is the case when the way of thinking changes when moving from one stage to another. It is a set of consecutive changes that proceed according to a coherent and integrated method and system, which appears in both the formative and functional aspects of the organism. This definition applies on both human and inhuman growth, as growth in this sense includes any kind of change that occurs (with the passage of a certain period of time) on any aspect of the organism, whether it is related to the anatomical structure, biological formation, physiological functions, or the activity in the environment in which the organism lives (Al-Arnousi 2015).

Growth is an integrated and sequential chain of changes that occur to the organism which leads to its completion and continuity, and that change carries the character of continuity and permanence of the individual and is related to the stages of life. It is a sequence of specific stages of changes that the organism goes through in a certain consistency and system (Saleem, 2002). Therefore, we must differentiate between change and growth, as change refers to the transition from one state to another, while growth is focused on the “dynamic” change elements in one direction. Accordingly, growth is a process, and change is a product, which is “those structural changes that move the organism forward to maturity, "a series of progressive changes of an orderly and interconnected pattern (Abdel-Moati, 2001).

2.3. Growth and Architecture

It is well known that the phenomenon of growth is related to organisms, and in order for this phenomenon to be linked and applied on architecture, we must realize that architecture is an organism within its environment with which it interacts, affects and is affected by, changes and responds according to the changing circumstances surrounding it and adapts to meet the new and changing needs.

2.3.1. Characteristics of Organisms and Their relevance to Architecture

There are many characteristics that all organisms share, which are: responding to their environment, growing and changing, reproduction, containing complex chemistry, maintaining homeostasis, built from structures called cells, passing their traits to their offspring.

2.3.1.1 Responding to the Environment

Organisms respond to the surrounding environment and adapt to changes that happen over time. These changes may be behavioral, structural, or physiological, that work on keeping the organism alive (Wilkin, 2015). This corresponds to the process of adaptation in architecture, which represents the ability of the building to accommodate changes in the field of performance or function to develop the building to suit the new external or internal requirements or needs in both the economic or social environment or the needs and aspirations of users, (Al-Muqarm and others, 2015).

2.3.1.2 Growth and Change

Growth process is one of the characteristics of organisms that indicate an increase in the quantity and quality. When seed is planted, it will grow and increase in size to a plant, but the stone does not grow under any circumstances because it does not possess the quality of life (www.courses.lumenlearning.com). This corresponds to all kinds of changes taking place in architecture, including the process of growing and development using a set of mechanisms, including addition which is of a cumulative nature in addition to the adoption and biological nature. Addition is associated with the development and growth of architecture across different eras, (Al-Qarah Ghuli, 2008).

2.3.1.3 Reproduction

Reproduction is the ability of an organism to produce new organisms. If no species of organisms can create a new generation, then these species will go extinct. The process of cloning is the creation of the next generation. Reproduction produces offspring that are genetically distinct and increases genetic variation within species (Wilkin, 2015). This is associated with architecture by establishing more housing units and service and industrial facilities within the city or in the surrounding areas, which is given the term of urban expansion, and urban expansion is closely related to the increase in the population. (Al-Abedi, 2018).

2.3.1.4 Maintain Homeostasis

The organism cells need a set of appropriate conditions in order to continue functioning such as temperature, and these conditions may change, so organisms work to always maintain the internal conditions through homeostasis, which is the ability to maintain a constant internal condition (www.courses.lumenlearning.com). This indicates one of the characteristics and orientations of sustainable architecture, where it plays a role in the process of building a healthy environment of all levels inside and outside the buildings according to ecological principles, and recycling used materials and use them in the construction and operation of buildings, by providing infrastructure services that ensures a safe and comfortable life for users, and works to achieve compatibility with the environment within a set of considerations and provide health and social requirements for users inside and outside the buildings. And since it is closely related to various sciences, it was necessary to keep pace with modern technology and take advantage of its capabilities in the process of organizing and maintaining homeostasis (Khurfa, 2018).

2.3.1.5 Built of Cells

The organism is built of a group of cells in a form of structure, so the cell is the basic unit of the structure and function of the organism. It is a biological phenomenon consisting of various systems that go through transitional states to reach the supposed balance point in nature and this is the reason for its constant change and transformation (Mahdi Ibrahim, 2016). Architecture consists of a group of structural units, which are three-dimensional objects, different in their size and shape, which results in a clear difference in the forms of structural elements that make up the built structures, which all form the solid mass of the solid structure,

and the surface component forms the basic unit of the surface structure and the linear component forms the basic unit of the structural building (Agha, 2010).

3. SECOND PART: VALUABLE BUILDINGS

3.1. The Value

3.1.1. The Linguistic Definition of Value

The concept of value in (Al- Maany Ditionary) came as the value is the singular form of values, and something's value means something worth or price that equals its cost. Values also refer to the religious, moral and social virtues upon which human life is based. As for Al – Waseet dictionary, the valuable nation reflected the meaning of being moderate and straight, and goods value means goods price, and the value of the human beings (www.almaany.com).

3.1.2. The Terminological Definition of Value

It is the standard to which everything in life (historical, aesthetic, architectural, functional, and economic) is attributed. Areas of value include types of monumental buildings such as historical temples, pyramids, castles and forts as well as historical buildings associated with historical value, or buildings considered a turning point in the course of architecture, such as the Bauhaus Institute building in Germany (Fig. 1), or a group of distinct architectural works of a particular architect, or buildings of that represent a specific architectural style in a previous historical era, or buildings that were inhabited by important figures such as the House of the Nation (Saad Zaghloul Museum) in Cairo (Fig. 2), and Mahmoud Mokhtar Museum in Tahrir Square, central Cairo (Fig. 3) (Trad, 2011).



Fig. 1. Aerial photograph detailing the Bauhaus building (www.syr-res.com).



Fig. 2. The front facade of the House of the Nation, Saad Zaghloul Museum



Fig. 3. Exterior view of Mahmoud Mukhtar Museum (www.albayan.ae)

3.2. Types of Valuable Buildings

3.2.1 Monumental Buildings:

It is the group of buildings or what is left of them, which were constructed more than 200 years ago, as they contain many patterns that indicate the era in which they were built, and they may still exist, or have been discovered through excavation in scattered cultural sites, and they may be outside the borders of the contemporary city or may be still located within the boundaries of its ancient buildings, such as the city of Babylon in Iraq, (Fig. 4), and the Parthenon in Athens (Fig. 5), and the Colosseum in Rome (Fig. 6), (Al-Shami, 2014). These buildings are known for their architectural value, which give a brief overview of the history of the city, as they convey the story of that era as a result the association with people, events, activities or even historical periods (Al-Nimra, 2014).



Fig. 4. Parts of the ancient city of Babylon, Source:
(www.arabicpost.net).



Fig. 5. External views of the Parthenon Temple, Source:
(www.mtnsh.com).



Fig. 6. Different views of the Colosseum in Rome, Source:
(www.omallqura.com).

3.2.2 Historical Buildings

They are buildings that were constructed more than 200 years ago. They do not differ in value, inspiration and interpretation from antique buildings, but they are still standing or preserving their architectural integrity, and are located within the surroundings of the contemporary city, such as Al-Mustansiriya School (Fig. 7), and the Coral School (Fig. 8), (Al-Shami, 2014). Historical buildings are those buildings which give you the motivation and desire to know more about the people who built them, and about the culture that they produced, as they possess a set of architectural, aesthetic, archaeological, historical, economic, social, as well as symbolic, religious, and political values (Al-Majidi and Others, 2015).



Fig. 7. Details of Al-Mustansiriya School, Source:
(www.commonswikimedia.org)

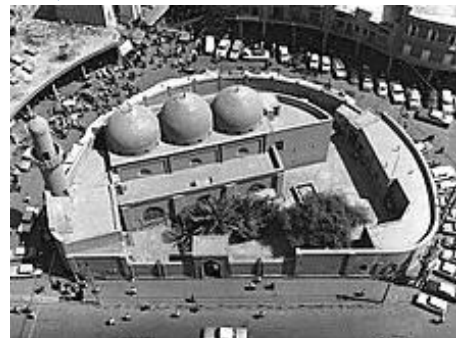


Fig. 8. External views showing the Coral School Building, Source:
(www.pinterest.com)

3.2.3 Heritage Buildings

They include buildings of historical and archaeological importance as well as those of artistic, scientific and social value, including decorations, fixed furniture and the environment

associated with them, as stated in *The Charter of the Preservation and Development of Urban Heritage in the Arab Countries*, (2017). They are less than 200 years old, and were established according to the local building traditions and within the style of that period. They are mostly located within parts of the urban fabric of the city, or may be individually standing after the demolition of some parts of that fabric, and al-Baghdadi House, which was built in the twentieth century as well as other buildings which were built earlier can be considered examples of heritage buildings (Al-Shami, 2014).

3.2.4 The Basic Approaches of Dealing with Valuable Buildings

After examining the concept of value and the types of buildings associated with it, the most important approaches used to deal with these buildings over time will be clarified here, which require making the appropriate change to the new requirements. According to the Al-Rayyis study, these approaches were divided into three main sections, which are as follows: (Al-Rayyis, 2006).

- 1- Preservation: It means protecting and keeping the existing building as it is without making any change. In other words, protecting it from any measure that could threaten its existence.
- 2- Restoration: It is the approach used to restore the building to what it was in a certain period of its history. The difficulty of this approach lies in determining the historical time period of the building that went through several stages, then determining the appropriate materials and components that must be preserved.
- 3- Rehabilitation: This approach can be applied if the following three basic requirements are met: accuracy in choosing the required function, knowing what are the permitted changes and identifying them, and finally the method used for the urban management of the area and surrounding neighborhoods.

This represents a functional reuse with making some required changes in the interior spaces of the building (the renewal mechanism). This method includes many interrelated concepts that all lead to changes according to the type of need and its determinants. This term (rehabilitation) is usually used in many different sciences, and it is a set of procedures that are taken to treat a failure or the inability of living and non-living beings to constantly perform the required functions, or that it has become inconsistent with the new age. Therefore, it has become necessary to make some changes that would give the ability to continue performing while considering the negative impact on the original value of the origin, and these changes may change the function of the old building or maintain the same function and continue, while preserving the elements of the valuable building. Among the benefits of this process is the sure guarantee of the continuity of the valuable buildings, especially if the building has been dedicated for a function with an economic yield such as museums (Al-Atama, 2007).

The way of dealing with the terms of a heritage value must be taken out of the philosopher (Muhammad Abid Al-Jabri) expression of “making a heritage out of the heritage” which means that when making any change, it is necessary to refer to the traditional methods and tools, but instead, we should use new cognitive means and tools from modern cognitive sciences, which enable us to make a qualitative and cognitive shift in the heritage, and to look at those valuable terms from a contemporary new perspective based on three main axes which are: theory, methodology, and application. The theory helps a person to build his self-model based on his objective reality and the level of his understanding of this reality. The methodology works on preparing for the transfer of theoretical ideas to the level of application that works to transform

these ideas and through the method into a technological applied reality (Morphogenesis mechanism) (Hamid and others, 2018).

In the method of architectural rehabilitation, there is a reconciliation between the oldest of the cultural processes, customs and social norms, with the ability to meet the renewable needs of contemporary society, so we see an increase in the rehabilitation of heritage and historical buildings with the existence of the rapid development. But from a functional point of view, most buildings have lost their original function or the function became useless, so their owners deserted them as they do not meet the new need. At the present time, we find an urgent necessity to use modern technologies in buildings, for economic purposes, as they need large amounts and effort as well as time in order to be restored to their original state. Therefore, this tendency has been found to make the appropriate adjustments and re-employ it to suit the new needs of the new era, (mechanisms of addition and adaptation), (Al-Fayyad, 2012).

It can be concluded from the above that the methods of dealing with valuable buildings differ according to the building type, age, constructional state and function, and each building has its own value that determines the approach of dealing with it in terms of architecture. Accordingly, methods varied between keeping it unchanged, or restoring parts of it to the original state, or rehabilitating it, which is a concept that includes the change in its various positive types. The need may require to change the original function of the building by relying on the adaptation mechanism for reuse, or maintaining its function using the addition and renewal mechanism, to suit the renewable needs, and adapt to the original for the building to suit the surrounding.

According to what has been proposed earlier, the research reached the procedural definition of the concept of functional growing in the valuable building, which is as stated below:

"All types of manifestations resulting from the change in the valuable buildings after adopting a number of mechanisms which would add a specific function or improve the same function to meet a new need or to increase the capacity, including the mechanism of addition, morphogenesis, renewal and adaptation, and by using a biological analogous strategy to make of nature a model for function and not only shape, and is often used in the interior spaces of the building for its association with the function (a qualitative change), which is followed by a change in size and shape (a quantitative change), taking into consideration the old building and its continuity in life".

3.3. Mechanisms of Functional Growing

After the knowledge which was presented about the concept of growth and growing, the value and types of buildings associated with it, as well as the methods of dealing with it over time, now we come to address the mechanisms used for functional growing in the valuable buildings which are: (addition, morphogenesis, renewal and adaptation).

3.3.1 Addition

The concept of addition in the language reflects the meaning of adding something to the text, and addition means an increase as stated in Al-Maany dictionary. While in Al-Mawrid dictionary, the word (addition) means growth, expansion, attachment and increase to something. Dr. Mahdi Al-Makhzoumi in his book (In The Arabic Grammar), mentioned the meaning of addition as a ratio and connection between two things in a way that does not express a complete idea with it, but rather adds something to another thing to connect and become as one thing, so the first acquires the characteristics and the attributes of the second. The addition refers to two meanings, the first means that it is an act or process that links the two parties with certain relationships (foundations), to reach the final result with the aim of increasing, growing

or supporting. The second meaning reflects a state of addition which means the state of attribution, (Khalaf, 2013, p. 13).

The concept of addition is associated with the science on the one hand, and art on the other hand, as it was associated with many sciences such as mathematics, which shows the quantitative nature of the addition, so the final result is equal to the sum of the parts. The quantitative nature of the addition is also evident in physics, where the mathematical process is on the one hand, and the qualitative nature, represented by the type of addition that regulates the process of physical joining and union on the other hand. While in chemistry, the qualitative nature of the added parts and the importance of the interaction between them are clear, as the whole is greater than the sum of the parts. The most important aspects related to the concept of addition in science can be identified as achieving growth, development, progress, and change. On the other hand, the concept of addition is associated with art through two aspects, the first relates to the artwork, expressing the product of the artist which is compatible and interactive with the environment, and the second is related to the artistic production process, where the addition in sculpting or drawing may be the addition of elements to an existing system, as the nature of these elements is different and they modify (change) the nature of the system. The most important aspects related to the concept of addition in art can be identified by achieving novelty and creativity in the style or meaning (Al-Qarah Ghouli, 2008, p. 6-10).

It is clear from the above that the concept of addition is closely related to architecture because it is a mixture of science and art and is considered one of the possible solutions to meet a specific need in a specific time, so it has a direct impact on many aspects, and since the addition means increasing and growing, it is thus indicative of growth as well on both the intellectual and material levels, which is one of the mechanisms of growing in architecture.

3.3.2 Morphogenesis

The concept of morphogenesis in the language reflects the meaning of forming, i.e. what is being formed, and the object is formed, e.g. the subject is formed of several elements: means consisted of, composed of, and the scene is formed means represented, and the fruit are formed means fruit are ripe. As for the word (forming), it is the infinitive of the verb (form), which in biology means the formation of new tissues. In geology, it means researching the changes that happened to the form of rocks, such as wrinkles, cracks, and the emergence of mountains. As for engineering, it is the external shape which defines the body (www.almaany.com). In terminology, it is a concept used in a number of specializations including biology, geology, engineering, photography, urban studies and architecture. This multiple use has caused a changing understanding that depends on the metaphorical and the true meaning of the word, and the original use depends on biology and the science of discourse, as it is concerned with tissues and organs of organisms and the process of forming the shape and the biological structure of them, and it includes a wide range of biological processes. It is a concept for the maintenance, regeneration and formation of tissues and organs, as it addresses the problem of biological form at many levels (İçmeli, 2014). It is a concept that refers to the processes of developing, changing and making special adjustments in response to a specific need, as in plant formation, which is a characteristic of the organism that helps it to adapt and develop over time. This mechanism can be used in architecture to achieve a dynamic, adaptive architecture capable of interacting and responding to changes, and explaining the role of digital technologies in achieving this, as in the project of The Water Cube, which is a swimming pool established in Beijing for the 2008 Olympics (Fig. 9). So, morphogenesis in architecture is understood as a set of methods that use digital media not as visualization tools, but as generating tools for

deriving and transforming of the form. Morphogenesis has many characteristics such as hierarchy, balanced organization associated with the hierarchy, dynamic changes that include deletion, transformation and addition that are made either by division as in cells or combination as in architecture, and the continuity that occurs with processes of formation at varying speeds but does not stop completely, and self-combination which is the process of collecting subunits and combine them to form the structure. Morphogenesis process in architecture depends on two methods; first is the form generation method, which depends on the representation of the digital form in the electronic space by software or using 3D scanning for the manually formed model (maket). Secondly, is the form finding method, which is achieved either by adopting the digital medium to produce the form, where the result is unexpected configurations, or by simulation from outside the digital medium such as growth simulation (Roudavski, 2018).

It can be concluded from this the importance of the mechanism of biological morphogenesis in achieving structural flexibility and benefiting from the principles of the organism and the growing mechanisms, to transfer them through biomimicry to architecture, where the integration of the relationship with biology can generate unique visions and aspirations that enable them to develop appropriate solutions to various needs which change over time and with different functions.

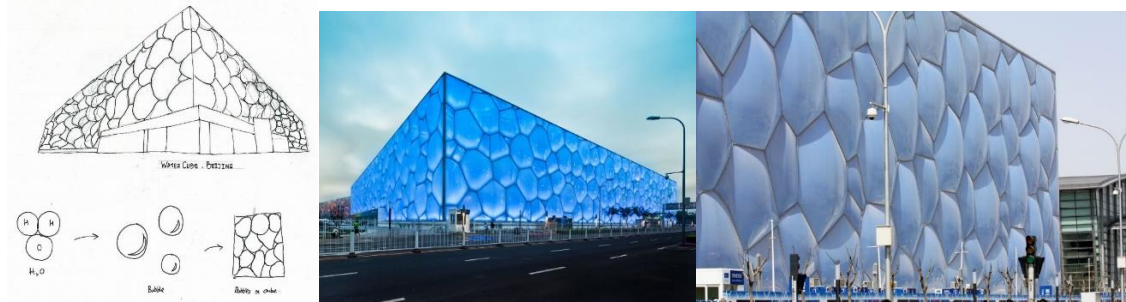


Fig. 9. The Water Cube building and the design idea inspired by soap bubbles. Source: (www.wanba001.wordpress.com).

3.3.3 Renewal

The concept of renewal in language came to mean making something new, and the word (new) is the antonym of (old). The renewal in language requires the presence of something with a certain state, and then was changed due to certain circumstances, so restoring it to its previous state is called (renewal), (Al-Selmi, 2014, p. 14). In terminology, the renewal of something does not mean removing it, and creating something new in its place, but rather means to maintain its essence, features and characteristics and renovate the ruined parts and reinforce the weak ones (Ibrahim, 2012, p. 13). Renewal is a human activity that comes from the individual and society, which goes against inactivity and lethargy, and takes the initiative to growth, development, and change in both thought and material, as it utilizes all available methods in all areas of life (Jilali, 2014).

The renewal in architecture includes the renewal of the architectural forms and the outer envelope of the building without compromising its essence, as the main idea for some people is the external inspiration of the shape of the building, without taking into account the important things that would cause a change as a result of that. The architect plays the role of a plastic surgeon who improves the external appearance of the human without affecting the inner beauty (the essence), although we are currently in an urgent need of a building that can be renewed automatically and spontaneously, such as the adoption of the metabolism theory at Nakagin Capsule Tower in Tokyo for the architect Kisho Kurokawa, whose idea was inspired by the

evolution and growth of the biological cell (Fig. 10). It is noteworthy that the concept of renewal in architecture is not related to demolishing the past with all its ingredients and replacing everything with new things. The architectural heritage is supposed to be considered, otherwise the work will be restoration and not renewal (Al-Mutairi, 2012). One of the most important characteristics of the renewal architecture is flexibility, especially in the interior spaces, as it helps to achieve the required changes easily and efficiently in a way that suits different needs over time, such as the constant flexibility, which includes structural changes and adding moveable dividers, and continuous flexibility which includes the division of spaces into load-bearing walls, and the growing flexibility which includes adding new spaces in addition to growing the space itself. And one of its characteristics is its ability to move in response to the forces affecting architecture as it serves to achieve environmental compatibility with the environment (Ramadan, Ali, 2018). One of the most important principles of renewal architecture is the multiplicity, which means each component of the system performs more than one function or meets more than one need, and the repetition, which states that every need within the system is met by more than one solution. This depends on the fact that there are many solutions within natural systems (Obioha, 2012).

It can be concluded from the above that the renewal process can be one of the growing mechanisms in architecture through which appropriate changes can be made, especially it is related to an existing building (changing something that already exists), and more importantly, it is concerned with the internal spaces (the function) and making appropriate improvements to meet the changing need through either dividing space into walls, adding new spaces, or the growing the space itself.



Fig. 10. Nakagin Capsule Tower in Japan / Source: (www.archdaily.com).

3.3.4 Adaptation

The linguistic definition of the word (adaptation) was mentioned in Al-Maany dictionary as being altered to another specific state or acquired a specific characteristic, and to adapt something means to adjust it to be compatible with something non-adjustable, and if a person adapts means to get along with the circumstances. In biology, it reflects a change in the structure or function of an organism, making it more capable of preserving its life or the survival of its species. It is a concept derived from biology according to Darwin's theory (the theory of evolution) as it indicates that the organisms are trying to harmonize with the natural world in which they live, in an attempt to survive (Al-Bahadly, 2014).

This concept was then used in psychology to denote the suitability of an individual to his function. The adaptation became more widespread when it came to explaining social behavior, and it included everything that an individual does to reconcile his behavior with the demands of the environment. The adaptive human behavior can be described as reactions to many of the

environmental demands and pressures in which he lives. We can understand and define adaptation as harmony, agreement, suitability and reactions to the changing environmental conditions, therefore it is the responsiveness in terms of the effect and being affected (Al-Hankawi et al., 2018). Adaptation in architecture is defined as the ability of buildings to accommodate the change as long as the building functions, and this change is necessary whether in the social, economic or physical environment and as per the needs of the occupants. So the building of the higher ability to adapt more efficiently and continue its function for the longest period of time will be used, which in turn will lead to the improvement of the building performance (Al-Bahadly, 2014). The adaptive architecture is designed to adapt to the surrounding environment as well as the occupants and other elements within it. The adaptation is achieved either automatically or by human intervention, and at many levels with modern technologies including the digital, such as (intelligent, interactive, collaborative, respondent, environmental and flexible approach) (Kheitou, 2017). Adaptive architecture (adaptive to the environment) is a group of buildings that are designed with the ability be changed or modified easily to suit the changes in the surrounding environment and thus fit with the needs before and after use (Ibrahim, Mohamed, 2018). The types of adaptation can be determined according to the changes that occur in the building as formal adjustment, functional adaptation, and behavioral adaptation (Al-Bahadly, 2018).

Therefore, we conclude that the adaptation is directly associated with growing in terms of performing the change process which occurs on the buildings, and of all types, the formal which is meant with the formal changes of the building blocks and facades, the functional, which is concerned with the internal changes of spaces, and behavioral which is related to the occupants of the building. These changes are made with modern technologies that depend mainly on digital technologies, and starts from the design stage to the implementation process.

4. THE THIRD PART: THE SELECTED SAMPLES

Three projects are selected for the museum function and of three categories (valuable buildings designed for a non-museum function, valuable buildings which have grown into museums depending on the adaptation mechanism, and valuable buildings which were designed as museums). The museum function was chosen because it requires a process of change continuously in response to the changing needs over time, and it was classified into categories to learn more about the application results of the mechanisms used in the process of functional growing, then applying the terms of the theoretical framework.

4.1. Valuable Buildings Designed for a Non-Museum Function (Moritzburg Museum Extension in Germany, 2008 by the architect Nieto)

The project is a castle that was built in the fifteenth century in 1484 in the Gothic military style, and in 1777, a military hospital was built in the eastern part of the castle in the Baroque style. In the seventeenth century, the Thirty Years' War affected the construction, especially the northern and western sides of the castle, and left them partially ruined. In 1904, the castle became a museum as the first extension of the museum was established in 1911, until the addition of Nieto in 2008. The castle is defined by four round towers located in its four corners surrounding a large central courtyard, (Marcus-A., 2014). The view of the Nieto extension is contemporary, yet it was able to integrate the extension in a way that preserves almost all elements of heritage. In 1911, the tower and the eastern corridor-like block were developed. In

1913, the southeastern fortress of the museum was expanded, and the western part contains the church which was built in 1505 on the northern side (Wallis 2012).

The Talmat building was established in the southern part of the castle in 1882 and was restored at the end of the twentieth century, and in 1904, the northern and eastern parts were restored to a usable state and the basement was renewed, until 1945 when the museum became one of the largest museums in Germany. In 2004, Nieto won the renewal competition and the last addition of the museum with improving the winning design in 2008 (Amy F., 2011). The latest development was in the form of an addition on the roof of the old building, though it was not very apparent over the old walls, which remained unchanged. This led to merging the old with the new in an unusual way that compels visitors to see the differences between the old and the new, where the rough texture and warm colors of the ancient stone walls against the white colors and the soft texture of the interior walls. The new design of the addition was based on the idea of a new surface similar to a large folding platform, rising up in certain areas and falling downward in other areas to provide natural light in the interior which leads to introduce the new exhibition areas. The design was made by building two modern vertical blocks, the first is in

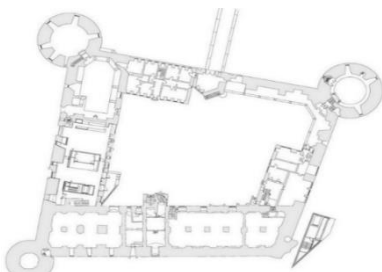


Fig. 13. Ground floor plan

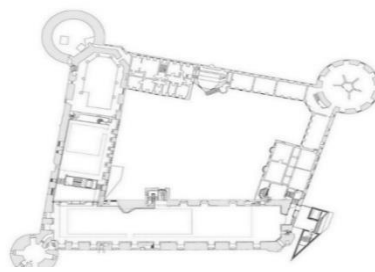


Fig. 12. Gound floor plan

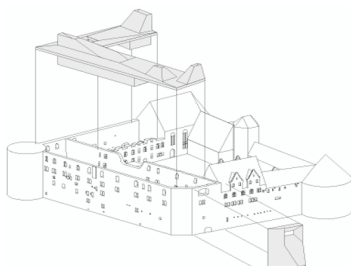


Fig. 15. Addition parts

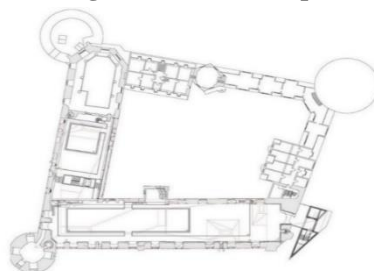


Fig. 14. First floor plan



Fig. 16. Different sections in the museum. The old red and blue represent the new part

the northern part to connect the horizontal levels and the second is a new tower with a height of 25 m, which allows access to the new exhibition areas (Roland H., 2008).



Fig. 11. The Moritzburg Museum

4.2. Valuable Buildings Grown into Museums Depending on The Adaptation Mechanism (The Museum of Regeneration of Shougang, CCTN Design, Architect, Bo Hangtao China, Beijing, 2019)

CCTN company for architectural design, led by the architect Bo Hongtao, developed a regeneration project aimed to convert Beijing metal melting furnaces into a vital museum and cultural center, where the factory's operations were moved out of Beijing before the 2008 Olympics to avoid air pollution, so the factory remained abandoned. A decision was later made to convert part of the old factory, which is one of the three melting furnaces, with a pool of water intended for cooling, into a cultural complex. In order to deal with such a complicated scheme, the Chinese architectural company developed a very creative solution that combines renovations and adaptive reuse of the large melting furnace, in addition to creating new spaces for art galleries, multicultural programs and service facilities for visitors, as the new design presents a strategy which combines preservation, constant protection and dynamic renewal (Riccardo B., 2019). The design company developed a three-point design strategy that combines preservation and renewal. The first of them is "seal up the old" which means to repair the old, which can be used in the new function and saving the distinctive urban memory of this land. The second is "remove the excessive" which means removing unnecessary parts after the reuse of the new function, but the process has to be performed wisely so that it does not affect the general goal of the main design philosophy of maintaining the archaeological value of the old function and its identification. Through this process, it is possible to open the door for dialogue between industry and nature. And the third is "weave the new", which means adding public spaces that include functions aimed to stimulate activity and harmony with the surrounding environment, (Sophia T., 2018). The design included a car park in the southern part of the additional cooling basin in the melting furnace in order to solve the public parking crisis in the industrial remnants sites, and a hall for underwater art galleries. In the southern part of the melting furnace, City plaza was added, which is a site for different social activities, which consists of a hall for temporary exhibitions, a public restaurant, and various activities that create interaction with the community on the one hand, and between the museum and the melting furnace on the other hand. The added blocks are arranged along the coastline independently that can be affected by the direction of this line with organic forms derived from the forms of natural coastal blocks. A large area of the original furnace is added to the urban exhibition halls to be merged with the new and to achieve the functional communication process between the new and the old. The site contains service platforms of different areas with different heights, which the design intended to make of them spaces for interaction between man and nature and the generation of urban activities, and therefore the various urban activities intersect with the architecture organically so that the manufacture eventually turns into urbanization (Maria E., 2018).



Fig. 17. The site plan

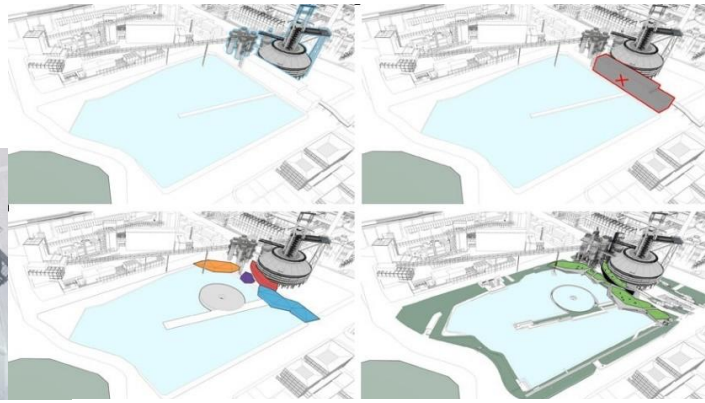


Fig. 18. Charts showing the stages of renewal and



Fig. 19. Some perspectives of the Shougang Museum

4.3. Valuable Buildings Designed as Museums (The expansion project of American Museum of Natural History, New York, 2020, by Studio Gang)

This expansion was known as "Richard Gilder Center for Science, Education and Innovation" with a total area of about 20,000 square meters of six floors, 80% of which will be within the current area of the old museum. Changes were made in the buildings of the original museum to accommodate the new addition, which will include a variety of new exhibitions and different educational spaces with modern technologies for display and learning, and it is indeed one of the largest museums of natural history in the world. The new building was planned from the side of Columbus Street within the old museum that was established in 1872, with a cave-like interior design of the new museum, as the new building consists of six floors carved with corrugated concrete walls and connecting bridges that are similar to the geological grooves and ice shapes which exist in nature (biological analogous), which gives a general description of the new addition, so that the cavities are inside the walls and are functionally used for display, in addition to areas for gathering and resting. The addition also includes a theater and a library, and the outer part will be covered with glass and stone taking into account the finishing materials of the old museum, so the new design maintains the existing heights of the museum building, which makes the facade the same height as the buildings on both sides, and the new design is consistent with the general condition surrounding the museum in terms of finishing materials and heights (Patrick L., 2017). The museum is located within a university campus dedicated for learning and displaying valuable collections. The facade of the new expansion was designed in the form of waves, so it is possible to say that it is a form which is mostly inspired by nature on campus. The new building has the features of sustainability in performance, such as good natural ventilation and rain water collection process. The project obtained a LEED Gold Certificate. With the beginning of the design process, parts of the

original structure of the building were removed in order to move the new building back to the inside to avoid affecting the garden, as well as replenishing the front areas with plants and adding seating areas. The design idea was inspired by tectonic forms and geological processes that exist in nature and by using high technologies to manipulate shapes, as finishing up the final design requires high- accuracy technology to reflect such effects from nature, especially in the design of curved and hollow interior spaces, in addition to reversing these curves on the façade. The inside corridors were designed in the form of rings, where the visitor continues to move without going back, (Miriam S., 2020).

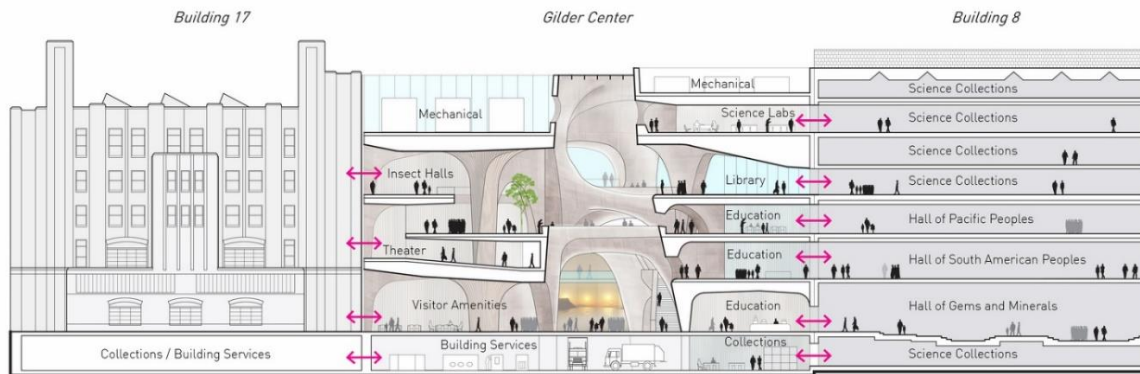


Fig. 20. The main sections of the museum.



Fig. 21. 3D model shows the American Museum of Natural History before and after addition.



Fig. 22. The main facade of the new addition.

5. THE FOURTH PART: THE PRACTICAL STUDY

5.1. The Theoretical Framework and the application on the selected projects

After presenting the detailed description of the selected projects, the variables of the theoretical framework terms will be measured on the practical study projects using the descriptive analysis method that is compared between the selected projects and by relying on the information form and the measurement form. The variables were measured by setting values ranging from (1-0),

as (0 = unachieved value, and 1 = achieved value) as well as adopting the analysis and statistics for the measurement terms.

5.2. Results of The Project Selected for Application

5.2.1. Results Related to The First Main Term (The Addition Mechanism):

The results of the application of the first main term on the projects selected for practical study showed that there is a variation in the ratios of its secondary term. The term (types of addition) achieved the highest rate of 70%, whereas (methods of dealing with the origin) achieved 50%. The table gives a clarification of the mentioned details. As for the achievement rate of the main term of the three projects, it was 60%.

5.2.2. Results Related to The Second Main Term (Morphogenesis Mechanism):

Through the application of the second main term on the selected projects, the results of the ratios for the secondary terms varied. The term of (form characteristics) achieved the highest rate of 53%, and (form types) achieved 33%, and detail are all shown in the table. As for the achievement rate of the main term of the three projects, it was 43%.

5.2.3. Results Related to The Third Main Term (Renewal Mechanism)

The application results of the third main term on the selected projects, showed a variation in the ratios of the secondary terms, as the term (multiplicity) achieved a rate of 50%, whereas (repetition) achieved 67%, and (renewal methods) achieved 78%, as illustrated in the table. As for the achievement rate of the main term of the three projects, it was 65%.

5.2.4. Results Related to The Fourth Main Term (Adaptation Mechanism)

The application results of the fourth main term on the selected projects for the practical study, showed a variation in the ratios of the secondary terms. As the term of (adaptation characteristics) with (adaptation methods) achieved the highest rate of 75% for both of them, and (adaptation types) achieved 67%, and detail are all illustrated in the table. As for the achievement rate of the main term of the three projects, it was 72%.

Table 2. The analysis and statistics of the measurement terms for the selected projects.

Main Indicators	Minor Indicators and Possible Values				The Selected Samples			Percentage rate	Percentage of each mechanism	
					1	2	3			
Addition mechanism	Addition types	Physical addition	Mass	material	1	1	1			
				shape	1	1	1			
				color	1	1	0			
			Parts	texture	1	1	0			
				material	1	1	1			
				shape	1	1	1			
				color	1	1	0			
				texture	1	0	0			
		Moral addition	Historic building		1	0	0			
			Heritage building		1	1	1			
			Related to a certain personality		0	0	0			
	Sum of Possible Values for Each Project			11		10	8	5		
	Percentage Achieved by Each Project				91%	73%	45%	70%		
	Methods of dealing with the original	Addition method	sequential		1	1	1			60%
			discontinuous		0	0	0			
		Addition Quality	Intercalated		0	0	1			
			Not Intercalated		1	1	0			
relationship to context		Linked to it		0	1	0				
		Disconnected from it		1	0	1				
Quality ideas added		new		1	1	1				
Sum of Possible Values for Each Project			Λ		4	4	4			
Percentage Achieved by Each Project				50%	50%	50%	50%			
morphogenesis mechanism	morphogenesis properties	Nature of morphogenesis	Hierarchical		0	0	1			
			regular		0	0	1			
			delete		0	1	1			
		The adopted method	Addition		1	1	1			
			Transformation		0	1	0			
	Sum of Possible Values for Each Project			ο		1	3	4		
	Percentage Achieved by Each Project				20%	60%	80%	53%		
	Types of morphogenesis	Shape generation	Figure representation digitally		0	1	1			
			Adopting the scanning mechanism		0	0	0			
			Model		0	0	1			
		shape finding	In the digital medium		0	1	1			
			Without relying on the digital medium		0	0	0			
Sum of Possible Values for Each Project			ο		0	2	3			
Percentage Achieved by Each Project				0%	40%	60%	33%			
renewal mechanism	Pluralism	Number of functions	1-5 functions		1	1	1			
			more than that		0	0	0			
		Number of shapes	1-5 shapes		1	1	1			
			more than that		0	0	0			
	Sum of Possible Values for Each Project			4		2	2	2		
	Percentage Achieved by Each Project				50%	50%	50%	50%		
	Repetition	functional	Repeat the same function		0	0	1			
			Repeating various functions		1	1	0			
		formal	Repetition at the part level		1	0	1			
			Repetition at the detail level		1	1	1			
	Sum of Possible Values for Each Project			4		3	2	3		
	Percentage Achieved by Each Project				75%	50%	75%	67%		
	Renewal methods	Divide space with walls			0	1	1			
		Add spaces			1	1	1			
		growth of the same space			0	1	1			
Sum of Possible Values for Each Project			3		1	3	3			
Percentage Achieved by Each Project				33%	100%	100%	66%			
Adaptation mechanism	Adaptive properties	Ability to accommodate changes			0	1	1			
		The ability to change			0	0	1			
		The possibility of harmony with the context			1	1	1			
		The possibility of communication with the old			1	1	1			
	Sum of Possible Values for Each Project			4		2	3	4		
	Percentage Achieved by Each Project				50%	75%	100%	75%		
	Types of adaptation	Between shapes			0	1	0			
		Between functions			1	0	1			
		Behavior (of occupants)			1	1	1			
Sum of Possible Values for Each Project			3		2	2	2			
Percentage Achieved by Each Project				67%	67%	67%	67%			

	Adaptation approaches	Interactive	1	1	1	
		Intelligent	0	0	1	
		environmental	1	1	1	
		flexible	0	1	1	
	Sum of Possible Values for Each Project		4	2	3	4
	Percentage Achieved by Each Project			50%	75%	100%

6. CONCLUSIONS

- 1- The research concluded that architecture behaves like an organism, as it possesses the principles and characteristics of organisms, affects and be affected by the surrounding environment and changes according to its determinants, so architecture must grow as the organism does to ensure its continuity and permanence.
- 2- Through the presented knowledge, the research concluded that growing is an ideology of insisting that architecture have a strong relationship with location, time and environment, in order to be convenient with the location and time and matches the human needs over time, and to be adaptive to its environment. It is not only an imitation of shapes in nature, but an analogy of method and performance and reinterpretation of principles.
- 3- The research concluded that the concept of addition is one of the basic concepts related to the growing in architecture and one of the mechanisms of its achievement. It is associated with science on the one hand and art on the other hand, and thus it is closely related to architecture because it is a mixture of science and art.
- 4- The research reached the importance of the mechanism of biological morphogenesis in achieving structural flexibility and benefiting from the principles and the growing mechanisms of the organism, to transfer them through biomimicry to architecture, where the integration of the relationship with biology can generate unique visions and aspirations that enable them to develop appropriate solutions to various needs which change over time and with different functions.
- 5- The research showed that the renewal process can be one of the mechanisms of functional growing, for its association with the presence of existing architecture, and its function is to make appropriate changes to meet a new need, especially it is related to internal spaces, as the renewal process is achieved through dividing the space with walls or adding new spaces or growing the space itself.
- 6- The research concluded that adaptation is one of the mechanism of growing, and is directly associated with it in terms of performing the change process which occurs on the buildings, and of all types, the formal which is meant with the formal changes of the building blocks and facades, the functional, which is concerned with the internal changes of spaces, and behavioral which is related to the occupants of the building. These changes are made through modern technologies that depend mainly on digital technologies, and starts from the design stage to the implementation process.
- 7- The research showed that the methods of dealing with valuable buildings differ according to the building type, age, constructional state and function, and each building has its own value that determines the method of dealing with it in terms of architecture. Accordingly, methods varied between keeping it unchanged, or restoring parts of it to the original state, or rehabilitating it, which is a concept that includes the change in its various positive types.
- 8- The research found through the practical study that the adaptation mechanism achieved the highest rate of growing after the application on the selected projects, which is (67%), while the morphogenesis mechanism achieved the lowest rate of (43%) due to the lack of

awareness in the use of digital technologies which possess effective tools to produce complex and free shapes, and have the ability to match the performance of organism in nature and on which the morphogenesis mechanism depends in the process of growing.

7. REFERENCES

- Abbas, S. S., Abdul-Zahra, G. N. (2014) *Planning Standards in A Sustainable Residential Gathering / An Analytical Study of the Growing Standard*, Research Presented to The Third Arab Housing Conference – Full Service Residential Cities / Housing Solutions, Baghdad, Iraq.
- Abdul Moaty H. M. (2001) *Growth Psychology*, 1st edn., Cairo, Egypt: Dar Qabaa for Printing.
- Wilkin D., Wilson N. (2019) *Characteristics of Life*, Available at: www.ck12.org (Accessed: 2015).
- Agha, R. (2010) *Technology of Architecture and Interior Design: The Impact of Technology on the Relationship of Form with The Origin in the Language of Contemporary Interior Spaces*, 1st edn., Amman: Dar Majdalawi for Publishing and Distribution.
- Al-Abadi K. (2020) Defining Urban Expansion, Available at: www.mawdoo3.com (Accessed: 2018).
- Al-Arnousi, D. O. (2020) *Growth Psychology*, Available at: <http://www.uobabylon.edu.iq> (Accessed: 2015).
- Al-Bahadly S., Al- Muqarm A., Al-Dabbagh S. (2014) *Adaptation by Reuse in Valuable Buildings*, 1st edn., Baghdad, Iraq: University of Technology.
- Al-Fayadh, N. (2012) *Redesign: Functionalism and Expressiveness in Additive and Revival Acts of Existing Buildings*, 1st edn., Baghdad, Iraq: University of Baghdad.
- Al-Hankawi W., Karim H., Hassan N. (2018) 'Adaptation of Infrastructure of Open Spaces in City Centers', *Journal of the Federation of Arab Universities for Engineering Studies and Research*, 25(2), pp. 1.
- Al-Majidi, B., Al-Taie, H. (2015) 'The Sustainable Preventive Preservation of Historic Buildings', *Iraqi Journal of Architecture*, 12(4), pp. 301.
- Al-Muqarm, A., Al-Dabbagh, S. (2016) 'Adaptation by Reuse in Valuable Buildings by Adopting Change in the Movement System', *Engineering and Technology Magazine*, 34(6), pp. 181-182.
- Al-Nimra, N. (2014) 'A Suggested Approach to The Rehabilitation of Archaeological Valuable Buildings in Gaza City', *Al-Qadisiyah Journal of Engineering Sciences*, 7(4), pp. 136.
- Al-Qarah Ghuli, A. (2008) *Creative Addition in The Contemporary Architectural Productions*, 1st edn., Baghdad, Iraq: University of Technology, Department of Architecture.
- Al-Rayyis, A. (2006) *International Conventions and Recommendations for Dealing with Architectural and Urban Heritage*, 1st edn., Sharjah, Emirates: Publications of Culture and Media Department.
- Al-Shami, H. (2014) *Policies for Preserving Archaeological, Historic, and Heritage Buildings*, 1st edn., Baghdad, Iraq: University of Baghdad.
- Al-Selmi, D. (2014) *Renwal in the Contemporary Interpretation, the Concept, Regulations and Orientations*, 1st edn., Egypt: Umm Al-Qura University.
- Amy F. (2020) *Moritzburg Museum Extension by Nieto Sobejano Arquitectos*, Available at: www.dezeen.com (Accessed: 2011)
- Atma, M. (2007) *Rehabilitation of Historic Buildings in Palestine, Case Study: The Experiment of Nablus City since 1994*, 1st edn., Palestine: An-Najah National University.
- Charter for the Preservation and Development of Urban Heritage in the Arab Countries* (2014), pp.17
- çmeli, B. (2014) 'Digital Morphogenesis in Architectural Design', *Journal of Gediz University*, pp. 1-2.

- Hameed, A., Abbas, Q. (2018) 'The Environmental Design between Heritage and Contemporary', *Iraqi Journal of Architecture and Planning*, 14(5), pp. 54.
- Ibrahim, A. (2009) *Al-Asranyoon and Mafhoom Tajdeed Al-Dayn*, 1st edn., Riyadh, Saudi Arabia: Al-Rashed Library.
- Ibrahim M, Muhammad D. (2018) 'The Concept of Biomimicry and Its Impact on Interior Design and Furniture in the Light of Digital Technologies', *Architecture and Arts Magazine*, 12(10), pp. 600.
- Jilali, B. (2020) On the *Concept of Renewal*, Available at: www.almothaqaf.com (Accessed: 2014).
- Khalaf, S. (2013) *The Urban Addition: Analytical Study of the Relationship between Addition and the Origin in Contemporary Urban Development Projects*, 1st edn., Baghdad, Iraq: University of Technology.
- Kharoufa, O. (2018) 'The Methods and Means of Applying the Concept of Sustainability in Buildings', *Al-Muthanna Journal of Engineering and Technology*, 6(2), pp. 171-172.
- Kheito O. (2017) 'The Concept of Adaptive Architecture and Its Applications on Building Envelopes', *Al-Baath University Journal*, 39(42), pp. 103.
- Mahdi, S., Ibrahim, I. (2016) 'Transformation in the Genetic System of Heritage Areas', *Journal of Planning and Development*, 12(34), pp. 3-4.
- Marcus-A. (2020) *Moritzburg Castle*, Available at: www.kunstmuseum-moritzburg.de/ (Accessed: 2014).
- Maria E. (2020) *CCTN develops the first blast furnace museum in china for shougang group*, Available at: www.designboom.com (Accessed: 2018).
- Miriam S. (2020) *American Museum of Natural History in New York Breaks Ground on Jeanne Gang-Designed Building*, Available at: www.architecturalrecord.com (Accessed: 2020).
- Obioha L. (2012) *Exploring Regeneration Architecture Principles in the Design of Ogota Blue Lake Resort Hotel*, 1st edn., Zaria, Nigeria: Ahmadu Bello University.
- Patrick L. (2020) *Studio Gang's American Museum of Natural History Expansion Set to Begin Construction*, Available at: www.archdaily.com (Accessed: 2017).
- Ramadan A., Ali A. (2018) 'Ecological Design of Living Systems in Interior Architecture', *Journal of Engineering and Sustainable Development*, 22(2), pp. 56-57.
- Riccardo B. (2020) *CCTN Design transforms former blast furnace in Beijing into a museum*, Available at: www.inexhibit.com (Accessed: 2019).
- Roland H. (2020) *Moritzburg Museum Extension*, Available at: www.archdaily.com (Accessed: 2008).
- Roudavski, S. (2018) 'The Path of Contemporary Architecture and Prospects of Renewal', *Rawafed Magazine*, 7(54), pp. 47-49.
- Roudavski, S. (2018) 'Towards Morphogenesis in Architecture', *international journal of architectural computing*, 7(3), pp. 348-355.
- Saleem M. (2002) *Growth Psychology*, 1st edn., Beirut, Lebanon: Arab Renaissance House (Dar Alnahda Al-Arabi).
- Shady D. (2020) *Almojam Aljame*, Available at: www.almaany.com.
- Sophia T (2020) *CCTN Design Announced A Scheme For The Museum Of Regeneration Of Shougang No. 3 Blast Furnace*, Available at: www.worldarchitecture.org (Accessed: 2018).
- Trad, M., Al-Omari, O. (2012) 'The Concept of Architectural Heritage and Methods of Preserving It', *The Third International Conference and Exhibition for Architectural Heritage*, 17(5), pp. 2-3.
- Wallis D. (2012) *Museums: A Beacon for Change for Heritage Buildings*, 1st edn., United States: School of Architecture, University of Hawai'i.