RES MILITARIS
REVUE EUROPEENNE D ETUDES EUROPEAN JOURNAL OF MILITARY STUDIES
Social Science Journal

The Role Of Flexibility For A Better Future Architecture

By

Rand Majed Ali Jaber
Email: rand.jaber271990@gmail.com

Asst. Prof. Dr. Arshad Abdul-Jabbar Al-Enezi
Email: dr.alanizi@gmail.com

Abstract

The current study addresses the issue of flexibility in architecture, which presents difficulties with all adjustments and ongoing needs by relying on cutting-edge construction techniques in the direction of a more flexible future architecture. Clarifying the part flexibility plays in ensuring a brighter future for the existing architecture is the research challenge at hand. In order to attain the optimal state for the architecture of the future, flexibility has to be used as a fundamental criterion in the research. In order to improve architecture in the future, the research postulates that flexibility should be built on a mathematical method. The study's main hypothesis is that flexibility based on a mathematical approach will improve the future of architecture.

The study defines flexibility as the ease with which something can be changed to satisfy a range of requirements. The research produced a theoretical framework for flexibility, its sorts and principles, the value of incorporating it into architecture, and the methods for doing so. Several architects, including Mies van der Rohe, Robert Venturi, Kenzo Tang, and Le Corbusier, whose domino structural system was employed in the field of concrete to achieve the flexibility of internal spaces, included these ideas in their plans.

One of the most significant findings drawn from the research is that recommending a more flexible future architecture than the one we now have leads to a brighter future for architecture. The flexibility makes the product of the architecture capable of adapting to any changes or new requirements of the user.

This is accomplished by prolonging the life of the default production and adopting a more adaptable structural system in response to the construction of the internal space and its alterations in accordance with the need. By fulfilling his future needs without altering the structure, this would benefit the user financially. The study thus highlighted the significance of establishing a link between growing flexibility and the ideal setting for future architecture.

Keywords: *Flexibility, Expansion, Adaptation, Switching, Transformation, Future Architecture.*

Introduction

Users are forced to take ill-considered and haphazard measures to switch or modify the building in order to meet their constantly changing requirements, which is a difficulty that has catastrophic ramifications in the future. As a result, the designer must research the user's basic needs in the future and take them into account in order to give the user the option of making alterations to the building that are appropriate for their needs without resorting to changing. If this adjustment is made in a way that obstructs the view or violates building codes, it will

exhaust the user physically and socially. The importance of flexibility in architecture seems to be the most practical and cost-effective way to solve this issue.

The Concept of Flexibility:

Linguistically, flexibility is the ease of changing things to adapt new circumstances (Oxford English Dictionary Online, 2011).

Some viewpoints:

- Kim considered that flexibility is "the ability to achieve a change in circumstances without changing the system". It meant responding to various circumstances.
- Groak, on the other hand, expressed flexibility by being able to make various physical arrangements. (Kim, 2008, p. 3).

This concept encompasses the design, implementation, construction, and ongoing process throughout the life of the structures because it offers the chance for modification with a change in the design process and performance assessment after the usage of the building by the user. This requires providing a new dynamic for the building to appear balanced and integrated in all its stages before or after the change (Khuzam, 2009, p. 307).

This is accomplished by modeling what occurs in nature and in harmony with its components, such as air, water, and the sun, in order to take use of them by creating architectural products based on them. According to the research, in order for the future architecture to be more adaptive and flexible in comparison to the existing architecture, it should integrate production with its surrounding environment. Looking at the adaptation of living organisms with their surrounding environment, it provides a benefit for architects by converting the architectural product into a semi-living organism that adapts to weather conditions and interacts with the environment and the surroundings, studying how to convert these elements into strength elements in the architectural product to resist conditions and weather factors. As a result, the architecture's products become more flexible towards future architecture. (Al-Mahdi, 2015, p. 3).

In light of the surrounding environmental, economic, and societal challenges, developments in the field of materials development and construction technology are accelerating, as several changes have occurred in construction, assembly and design methods to achieve the user's increasing requirements. It was necessary to move toward more adaptable architecture applications to meet the demands of a dynamic society by offering creative design visions that are shaped in accordance with the circumstances with the goal of fusing the present needs with the anticipated potential changes in the future to make them more flexible and adaptable. It is necessary to employ the principles of flexibility in architecture to make it more flexible and adaptable to any future changes in the functional or potential environmental level through the use of advanced construction systems, provided that necessary modifications are allowed in the future in accordance with the user's requirements and desires. The research suggests moving towards flexibility, studying its principles and analyzing its applications to enhance the use of modern construction techniques for future architecture, in order to achieve greater flexibility.

Types of flexibility:

Internal flexibility: It is the possibility of changing the shape or function of spaces.

External flexibility is when a building is expanded by adding an entire block with the intention of adding a new function or expanding it to meet those needs. It also refers to when exterior changes are made without affecting the interior for reasons related to the development of the building in accordance with new functional, social, and aesthetic requirements (Al-Bajari, 2008, p. 126).

Flexibility in architectural production allows modifications and changes to be made without harming the construction of the building. This is evidence of understanding the important role of these modifications in planning the architectural output for users. (Tanous 2013), (Estaji, 2017).

Neglecting the requirements and needs of users when designing a dwelling leads to random modifications by the user in response to his requirements, such as breaking down a wall for the purpose of opening up space. This flexibility is unhindered in terms of the physical accessibility of the structure. (Tanous 2013).

3- Flexibility in architecture:

In the context of merging the term flexibility with architecture, Anas stressed that the advanced construction techniques adopted in the design of buildings give an opportunity for the elements of the interior space not to be rigid to allow for more flexibility and beauty in the space. He added that these flexible buildings are a new type of architecture that embraces challenges and changes through the deep employment of new technologies, which increases the susceptibility of architecture and its ability to face challenges such as population density or catastrophic events without losing sight of aesthetic considerations. Therefore, flexible architecture is defined as “architecture that believes in responding to change rather than remaining idle” (Anas, 2017, p.510).

The norms of architecture and society that evolved to meet the needs are differentiated by flexible buildings as well. Anas underlined that flexible architecture contains a design approach to support one's imagination and notion about future development in response to a set of uses. (Anas, 2017, p. 211).

Flexible is "the building ability to adapt to specific events and actions through functional, spatial, or physical modifications," according to Michael Prins. Keep in mind that although these occurrences are anticipated, the exact timing is unknown. (Prins, 1992).

This opinion is contrary to the opinion of Hertzberger, who considered flexibility solutions as an open ended solution and that flexible designs do not give one solution that is better than the rest of the other solutions. Flexibility is a term with multiple meanings and its content lies in transformation and adaptation, the ability to modify, respond and adapt, and the ability to deal with expected changes in a specific place and time and under insightful readings of environmental technological functional considerations (Kim, 2008, p.3&4).

Acharya emphasized that flexibility in architecture is devoid of limits, as it corresponds to changes in space and time, purpose, size, or shape. Acharya expressed flexibility by saying “that flexible architecture is one that constantly reflects the way we realize the possibilities and rules of life and restructures them in order to meet the needs of the current era and that it pushes the transformation of architecture into a more efficient and sustainable cultural product for a dynamic society”. Flexible architecture, in its view, reflects the way in which we realize the possibilities of life to meet the needs of the current era, while trying to push architecture to form a highly qualified cultural product for a dynamic society. Kronenburg puts forward his

opinion on a more flexible future architecture. He says it is "a flexible structure that is complete once people inhabit and use it, and that it aims to embrace the changes and challenges of a dynamic world. It requires situational design to integrate the demands of the present with potential changes in the future" (Acharya, 2013, p. 23-24-80).

According to Metwally, flexibility with regard to metal construction and furnishing products and systems means the ability to adapt with changes in the environment and the requirements of users of these products. It is one of the general goals on which how long these products depends last and continue (Morsi, p. 47).

Gierbienis also emphasized the term flexibility "the ability of architecture to adapt to human needs. (Marcin, 2019, p.8).

As for Till and Schneider, in their view, flexibility is the process of accommodating change in housing while addressing the needs of users, whether current or future, such as providing diversity for the design of units such as adjusting the unit and adapting it with time while allowing facilities to absorb the new function (Kim, 2008, p.10&15).

The role of flexibility in architectural designs:

The ability to modify and change the functional and spatial systems of a structure is a sign of flexibility in architectural production. Over the physical life of the building, this system adjusts to the spatial and temporal changes consistent with many functional requirements of the structure, guaranteeing that the building continues to be used for the longest time possible and with the highest level of quality. This feature that allows these modifications to be made is called design flexibility. The physical components that make up spatial systems are stable and permanent, but human and functional needs are always changing as a result of spatial and temporal circumstances, which is in contradiction with the physical parts capacity to remain constant and stable. This contradiction justifies the role and importance of design flexibility as an urgent option in order to be in line with the economic feasibility of the building and with the recommendations of sustainable development regarding the functional ability to live and to respond to any change in the longest possible period of time. This design flexibility relates to the behavioral, social, economic and cultural aspects of the user's desires and needs with his future developments while preserving the user's socio-economic stability. The lack of design flexibility in any building in a way that does not respond to the new requirements of users will negatively affect the material economic aspects or the bad social aspects in terms of connection to this place. (Al-Bajari, 2008).

Designers must pay attention to the principles of flexible architecture while benefiting from its principles that make it meet the requirements of society and guarantee it an important role in future architecture. These principles are:

Flexibility principles:

How can this term of flexibility contribute to developing a new style of structural systems for a better and more flexible future architecture? It does so through applications with interactive construction, foldable and prefabricated, mobile and transformable, and other directions that represent the content of flexible architecture.

According to Kronenburg, the principles of flexible architecture are:

– Adaptability (structural flexibility, possibility of modification)
– Interactivity (reuse, prefabrication)

– Mobility (can be assembled and dismantled, multi-use, structural strength with light weight)
– Transformation and folding (simple and self-construction, special design, ability to grow with expansion).

Adaptability: is the ability to change according to circumstances, which is the best that can be learned from nature. This adaptation is trying to go towards it and use it in architecture to increase its flexibility in the future. The term adaptability illustrates the need to recognize that the future is unlimited and change is inevitable and the framework is an important element to allow such change to occur. Adaptability is one of the basic features that must be available in flexible architecture, with the possibility of using the open building strategy in adaptable and flexible architecture that achieves continuity in the process of change in line with future needs. Image (1). (Acharya, 2013, p. 25).

Image (1) *Structural images of facilities showing the ability to adapt (internet web)*

Interaction is the architecture in which the interaction between the user, the building and the devices takes place. Interactive design relies on the technological systems that are used to create interactive buildings. Intelligent building systems are used in order to create an interactive structure that responds intuitively to the requirements of users. Image (2).

Image (2): *The Olympic bath in China, a flexible hut with an interactive interface (internet web)*

Mobility: Codrescu defined mobility as the mobile architecture, which is "a structure that represents physical movement and architecture that changes places in a limited time scale". The term mobility means that which can be physically folded and moved from place to place, given that non-movable things restrict the freedom of the individual. The clearest example of mobile architecture are projects that are implemented in times of emergency or when needed, such as mobile caravans and Bedouin tents. Today, it produces many prefabricated, multi-use metal facilities that are useful for business, education, industry, housing, and health care, and are highly flexible with the possibility of reuse in keeping with changes according to needs. Image (3). (ibid)

Another example of flexible architecture that can be moved is the football Stadium 974 in Qatar, which has a capacity of 40,000 spectators and has a low cost. It is the stadium where the 2022 World Cup final matches were hosted. It is named by this name because it is composed of 974 dismantle containers. It is the international telephone code for a cat country, where this stadium can be completely dismantled and used elsewhere for another project or donated to poor and less developed countries in the world. It is the first temporary place in the history of the World Cup (Wikipedia / Link 7). Image (4).

Image (3) *Structural images of facilities showing mobility (internet web)*

Image (4). *Stadium 974. Source: Wikipedia*

As for transformation, it means buildings capable of transformation, which Jantzen described as being able to change their area and appearance through the physical change of their structural components or their external and internal surfaces, as in Figure (4) and (5). Here, it is necessary to allow for a change in the nature of the architectural environment, as the fixed structure, when the characteristics of transformation enter into it, adds a touch to this performance. The building becomes movable at the push of a button through a simple or complex process where the shape of the building changes and looks as if it was alive. The transformable structure has the ability to interact with external conditions and respond to them by opening windows, roofs, or parts of the facade. This type of control removes the barrier between the inside and outside (Acharya, 2013, p.p. 26-30).

The best example is the mobile house in Iran, which was designed by an Iranian engineer in Tehran, where the size of the house can be changed with the change of its façade to control the entry of solar radiation. Thus, the temperature of the house changes (link 3). Image (5).

Image (5) *The mobile home in Tehran.*

It must be noted that flexibility cannot be limited to the four previous principles, but prefabrication can be added. Prefabrication means "manufacturing parts in the factory so that the building consists mainly of assembling and merging standard parts". (Inani, 2012, XI). This principle is another form of flexibility in facilities, which is useful for getting a better idea of intelligent analysis systems to discover the future need because of its characteristics and its ability to change and flexibility such as the ability to modify, disassemble and expand with addition, extension, deletion, growth and transition. Image (6 & 7).

Image (6) *Structural images of facilities showing the ability to transform and fold (internet web)*

Image (7) *A polyhedral dome with triangular units formed by several images (internet web)*

Al-Araji states that the designer's main concern is flexibility to achieve adaptability with the possibility of modification to deal with user's future requirements. This is implemented according to the expectations of the designer or the investor clients about these future requirements (Alaraji, 2012, p.2). Metwally believes that there are five elements that achieve flexibility in system design, namely:

- Flexibility of connecting elements
- Flexibility of standardization
- Flexibility of replacement and substitution
- Dismantling flexibility and re-installation
- Flexibility of addition and deletion. (Morsi, p. 51)

Methods of achieving flexibility in designs:

These methods appeared within the proposals of architects interested in achieving them in their designs. Among these methods are:

First: the open space of Mies Van Der Ruhe:

It depends on the flexibility of the internal space, as it presented a new vision in the box building and called it universal space. It is a space suitable for all activities to take place inside, and it can be divided with high flexibility and great freedom according to the needs through the use of light partitions that are not restricted in its distribution by the fulcrum. Mies says "that the purposes that buildings perform change, and we cannot bear the expense of demolishing these buildings, so we put Sullivan's saying (form follows function) aside and build a practical and economic space in which we can put the function. It is the structural construction in the projections that helped the designer to achieve this, with a focus on the fluidity of the spaces from the sides, which achieved transparency in the box. The glass facades prevailed in works based on the thought of the international style, considering that the internal space is the basis of the building. Image (8). (Hassan, 2001, p. 350)

The aforementioned indicates that there is a contradiction between the principle of flexibility and the principle of form following function.

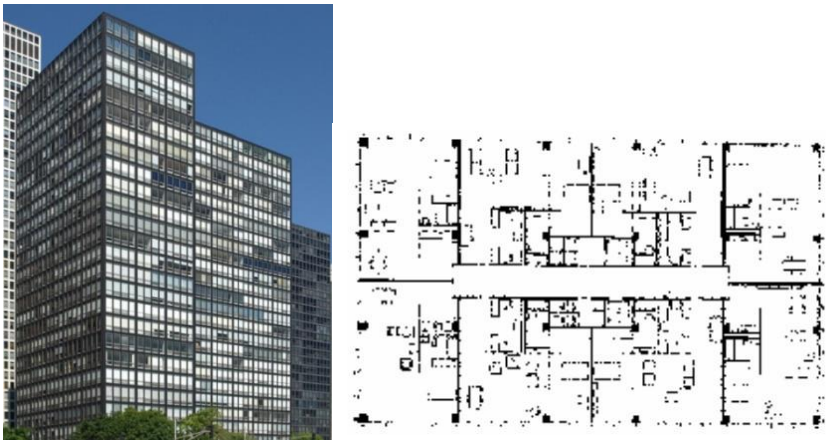


Image (8) *Plan and facade of the Lake Shore Drive Apartments building in Chicago. (Hassan 2001 & link 5)*

Second: the space with multiple functions by Robert Venture:

The volumetric formation of the building is the fixed part, while the function is the constantly changing part. This is what Venturi referred to when analyzing the inner space. The goal of the interior treatment of any building is by surrounding the interior space instead of directing it functionally by creating a pure multi-functional space so that the room is designed to be a general function and not a specific one. This is in the case of fixed space formation. Multifunctionality in the room is the best solution for flexibility with the help of multiple elements such as movable furniture instead of a movable partition, while enhancing sensory flexibility rather than physical, provided that the requirements of permanence and durability required in construction are maintained.

Third: Structural flexibility according to Kenzo Tang:

Being flexible is one of the key characteristics of living things, and as architecture resembles a living thing more than anything else, it must also possess this quality. In order for it to expand and flourish with the potential of replacing its worn-out pieces, Tang emphasized the importance of its presence in the architectural production. He made a distinction between architectural spaces based on the user's shifting demands and the time period in which they are

appropriate. He considered the service and construction elements as fixed elements, with a structural service role, with a spacious and flexible space that could be divided with high flexibility through the variable elements (Hassan, 2001).

The aforementioned indicates that the flexibility according to Tanim is associated with the phenomenon of succession, that is, when a nail is removed and a new one comes in its place. Flexibility is one of the important qualities of a living organism. Thus, In light of the fact that architecture is increasingly like to a living body, he underlined the importance of its presence in the architectural process. Despite Tang's argument for an analogy, the analogy does not imply the necessity of a perfect fit with the architectural examples. This idea of Tang is his own and it is not necessary to generalize it.

Fourth: Metabolism movement:

Metabolism is the crucial procedure in charge of ensuring the survival of the organism. As architecture can be considered more like a living organism, as we mentioned, it must have structural vitality (multiple floors). Its products should be characterized by the possibility of growth in accordance with the continuous and changing requirements, since the jobs and the way they are used are changing from one generation to the next. The production must be carried out in a way that allows functional dynamism in it, in a way that is compatible with the new job. Here are certain types of spaces distinguished as follows:

- Unchangeable Spaces, such as movement and service elements, which are made of materials with a long life span.
- Changeable Spaces in which human and functional needs change and are made of materials with a short life span relative to the first.

This type is the one that has the characteristic of flexibility, so it must be subject to change.

After that, the concept of flexibility, the Metabolist Movement, was introduced based on the following elements:

- Fixed elements, such as the internal cores of the building, in which all services are gathered.
- The non-fixed elements in their location according to the requirements of the users and the functional spaces of the building as in the form below.

The concrete capsule housing (Nakagin Tower) by the Japanese architect Kisho Kurokawa in 1972 is a good example. It is the building that most expresses this movement (Image 9), and it is a model that expresses flexibility. As it consists of 140 rotating capsules at different angles and stacked at a height of 14 floors with pre-equipped and adapted to suit the different functions of the dwelling such as kitchen, living, sleeping and reception, and it is fixed on a core and matrix. The most important thing that distinguishes it is its flexibility in design with the possibility of modification and expansion, and the possibility of switching to another unit from the same building or a new one due to the technology developed by Kurokawa, which made each capsule fixed by means of screws only in the solid axis, so it was interchangeable. These prefabricated units are transported to the site by trucks. It is characterized by circular windows with the integration of the bathroom and bedroom, where the capsule is lifted by means of a crane and inserted into the shipping container, and then fixed to the pivot steel rod by means of this crane (ibid.).

This tower was built for the purpose of housing travelers in Japan, which is a model that represents flexibility in architecture through the possibility of replacing units when needed, and connecting any unit with the central core and replacing it. Its dimensions were 4 by 2.5 meters, sufficient for housing one person, with the possibility of expansion by connecting the

capsule to another capsule. This type of new technology, represented by capsule units, gave a solution to architectural problems. This huge urban building was constructed consisting of a strong, cohesive part such as the box structure and the spatial truss, and a group of prefabricated box-shaped capsules as shown in Figure 10,11,12,13. The owners of this movement expect that the future of architecture based on this idea (capable of extension) will be better. (link 1).

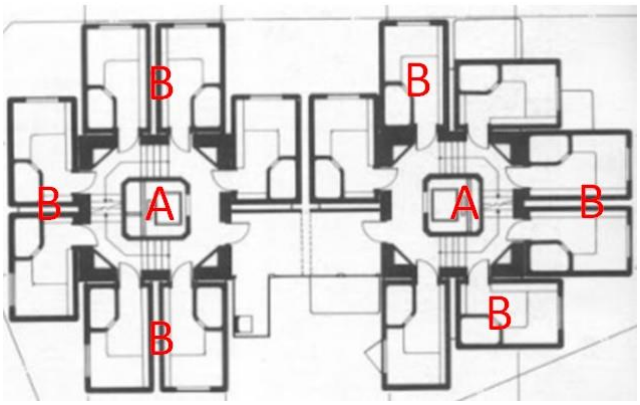
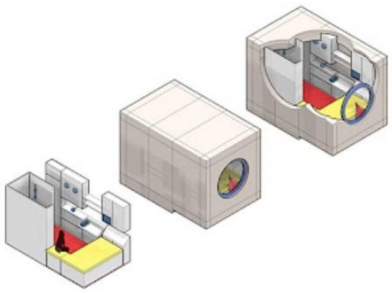


Figure 9/ *Fixed items A and Non-fixed B.(Link 1)*

Image (11) Link 1. *The capsule from inside and outside, which is prefabricated and transported by trucks and lifted to be fixed on the steel axle.*

Image (10). The facade of the tower showing the capsule units. /source1



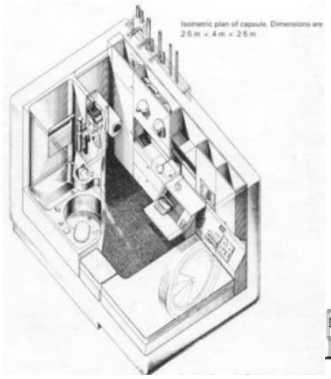


Image (13). *The prefabricated capsule units inside and out/ Source 1.*

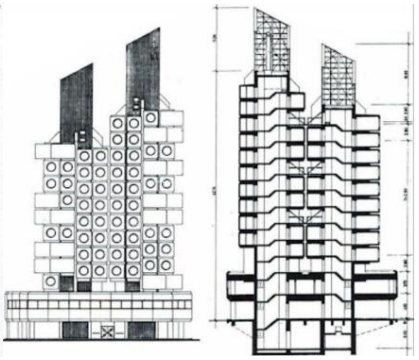


Image (12). *A vertical section of the tower/ Source 1*

This movement, which was established by a group of young Japanese engineers, represented an advanced thought for future architecture with principles derived from the biological functions of the organism and from the idea of metabolism in the body of the organism. Scientifically, this term denotes the processes involved in building protoplasm with its consumption in the body of the organism in relation to chemical changes in cells that provide energy for vital activities to produce new cells that compensate for what is consumed. It is a

basic process upon which life is based. This method was employed in both technology and architecture, where designers utilized it as a foundation to build buildings with structural life similar to the vitality in a live organ system. They view human society as a constantly evolving process and deal with it as part of the continuity of natural existence in plants and animals, while considering technology as a natural extension of humanity. It is contrary to the European belief that the growth of cities is a result of the conflict between humanity and technology.

The philosophy of this movement is based on the principle that everything changes in life, such as a living organism, as well as architecture and its existing products to continue for several years. However, with the succession of generations, the benefits differ within the spaces, so the building is disproportionate to its age. Therefore, buildings must be made so that they can be easily demolished and replaced with new ones commensurate with the new benefits. Because of the changing aesthetic and utilitarian needs, the spaces are not built to live for long centuries, as is the case in past ages, because the needs change through generations or in one generation itself to suit the rapid development of technology that did not exist in the past, such as now. (link 1).

It is concluded from the above that:

- The demolition process is the last stage that is relied upon in order to obtain an empty or smaller place for a new building. Flexibility will not be for the building, but for the internal spaces for reuse, which would lead to space flexibility (temporal flexibility).
- The metabolism, which depends on the use of matter to build cells, is regenerative. This process was used in architecture, and the idea of the owners of this movement was to use material to build cells.

Fifth: the Domino system (Le Corbusier):

This system is among the concepts developed for structural theories in the field of reinforced concrete, which achieved both the concept of flexibility for the internal spatial formation of the horizontal projections of buildings with free projection (Abdul-Gawad, 1977, p. 53). Its discovery is due to the architect Le Corbusier, who built a concrete structure called Domino consisting of six pillars or columns of concrete with three horizontal flat surfaces based on these columns and linked by a free ladder (image 14). According to the type of relationship specified by the designer, the nature of the shape of this system (team x) can be changed.

Image (14) *the domino construction system/ link 2*

The concrete structural system made it possible to dispense with the thick wall as well as any supporting structural element in the building, while relying on the column as a structural element. As a result, complete independence was provided for the internal partitions, with the

freedom of the internal spatial distribution of this building. In this regard, Sigfrid Giedion stated that Le Corbusier was able to employ the concrete structure in making an architectural expression that helps in the design processes and explains the link between the user's needs and the concrete construction. He came up with an idea of unprecedented lightness to create a dwelling in particular (Hassan, 2005, p. 8).

This system was used by the architect Le Corbusier to exclude interior partitions from their structural concept. Nevertheless, the formation of these internal partitions did not deviate from the traditional concept in the process of separation, kinetic communication, and the containment of spaces within the system of cells connected to each other through doors and corridors, as in the Savoy Villa.

The Villa Savoy in France to apply the concept of flexibility in housing:

Le Corbusier designed several residential villas between the 1920s and early 1930s. The most important concern of its design was to test its new design principles (principles of general modernity), which are:

- Raising the building off the ground through the use of pilots, allowing the extension of the ground from under the building while benefiting from this space for various flexible purposes.
- Free or Open Plan, that is, the possibility of placing walls in any place desired by the designer without being linked to the structural system.
- Roof Garden.
- Free Facade.
- Long horizontal ribbon windows achieve communication among the interior and exterior spaces.

These principles achieve artistic, social and economic benefits, which the designer applied in several projects, including the Villa of Savoy in Poissy 1929-1931. (team x). After implementing this project, it was announced that the technology of solar breakers, which was proposed to address the problem of glass windows in hot weather, is among its principles.

The revolution in the world of building technology had a great impact on the creative processes of architectural designs, which whereby the famous architect Le Corbusier benefited from. He developed the so-called flexible domino system consisting of a structure with columns with a small cross-section bearing floors and ceilings (horizontal slab) and linked to the columns via a ladder, which is the only fixed element, that gives flexibility margin 1 in each of:

- The free plan of the villa with a load-bearing structural construction system, with the replacement of the load-bearing structural walls with design partitions distributed on each floor according to the user's desire. Figure 15.
- The free façade with continuous windows and the protrusion of the façade to enable continuous opening in it, regardless of the internal distribution process in the spaces. This achieves the flexibility of the interior space with the aesthetic of the façade that is independent of the building plan and achieves the aesthetic of volumetric freedom.

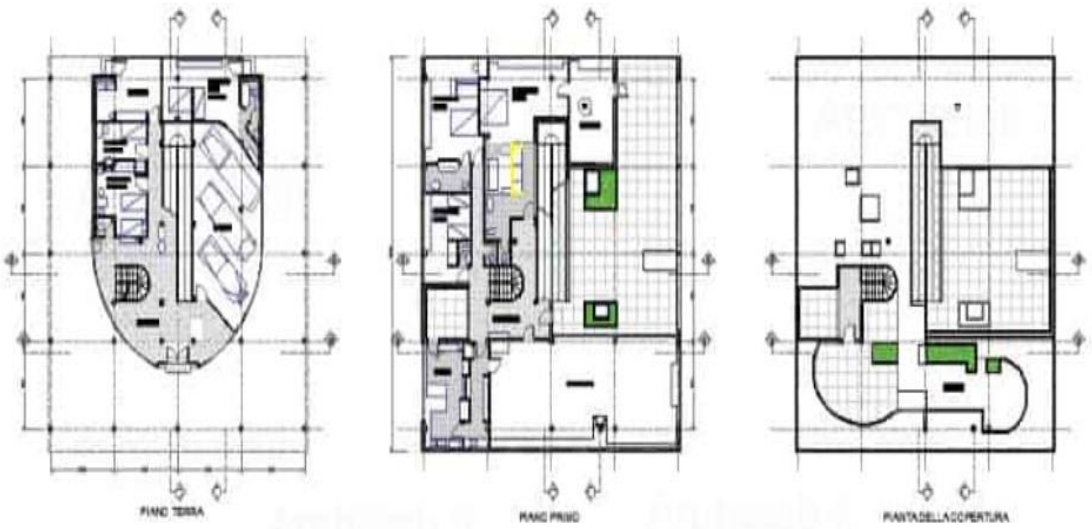


Image (15) *the free plan of the villa. Link (6)*

We note the designer's point of view about the classic box, which emphasizes the preservation of the shape of this box, while making an empty space in it to allow the integration of both internal and external spaces. This idea created a new look for the interior architectural space. The designer confirmed that the outer space flows towards merging with the inner space through the cavity of the box, with the ability to put the inner walls anywhere he likes, regardless of the different floors of the building. He also used new techniques in construction materials and methods, as he relied on reinforced concrete in the building in which the designer excluded the interior partitions from the structural concept through his use of the domino system in order to achieve flexibility (team x).

Robert Venturi discussed the so-called Flowing space, or the connection between the interior spaces of the structure and the outside spaces of the surrounding environment, on page 172 of his 1987 book Complexity and Contradiction in Architecture. That is, the flowing space that sought to achieve continuity between the two types of spaces, as it is known as “the space connected to the outer space spatially in one unit. It is a space that does not contain any internal obstacles, even if it does not open to an external space (Al-Akyabi, Hassan, 2002).

The spatial configuration of the building came within the so-called box building with openings with limited spaces in which communication between the inside and the outside is achieved (Mustafa, 1979, p. 127).

Because this communication is limited, some architects sought to demolish it within the mechanism of achieving connection. After that, strategies for reformulating the notion of this box structure appeared, such as Le Corbusier's Villa Savoy, where the designer communicated his concepts via the cubic building's abstracted shape of the space with a variety of spaces generated in a free manner. Figs. 18 and 19 show the emptiness beneath the structure raised on columns, as well as the creation of a transparent interaction between each of the building's interior areas and the surrounding exterior environment seen via the strip windows. As a result, outside space began to enter the structure.

Image (18). *Le Corbusier's method of demolishing the box building by raising the building on pillars and using strip windows to communicate between the inside and the outside / Wikipedia*

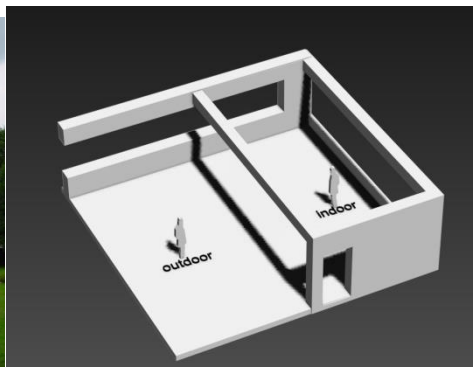


Image (19) *illustrates the relationship between garden space and living / prepared by the researcher*

The designer used the so-called fluid space in the formative treatment of the building, where he placed within the spaces of the first floor the living room in order to communicate with the space of the adjacent garden. This is in order to unify the space by means of the extended striped glass facade to achieve kinetic and visual contact with the expression of openness between the internal and external space surrounding the building within the framework of its borders (Shirzad, 1999, p. 384).

Everything that has been examined in this research is geared toward a brighter future for architecture, as the research offers a more flexible future architecture by using its principles to create structural systems that are more able to adapt to potential future changes. Future changes might potentially be made to be user-compatible.

There is a need here to know where the future of architecture is heading, as there is flexibility from another point of view, since the principles of flexibility are multiple and the mind has the ability to produce more of them. The issue is endless and the principle of adaptation is very high, as the principles of flexibility were reviewed with examples. The research suggests adding mathematical directions or applications in flexibility, provided that they are directed to form a future image of architecture, as the research suggests relying on applied mathematical intelligence in analyzes to understand the path of architecture, where it is heading, with the aim of:

The relationship between (user's need and structural systems) & (user's need and space)

The first step towards flexibility or adaptation, which relies on prediction through programmed mathematical techniques in the analytical process, is to understand the link between (the user's need and structural systems) & (the user's need and space). Hence, the demand for intelligent analytic systems to identify or better understand the future requirement evolved. We require predictability since the study generates test or experimental research criteria or terminology. The recommended criteria are as follows:

- Structural-systems relationship for one person.
- The relationship of space with the need of one person, including space, appropriate heights, and appropriate sizes.

When determining the future need through mathematics in architecture, we will obtain more predictive frameworks about the future by reviewing an illustrative example with the

possibility of dealing with the future. This is what the research seeks, as in this research it was clarified who considered that the future needs are specific. Another section considers it indefinite, and the other considers it definite but not specified in time. All these cases talk about future needs, so here these needs must be linked with the future. We need here any frameworks for the future to know how to adapt to it through architecture and its more flexible output. If this predictiveness, that we get through mathematical intelligence happens, we will know what will happen. This is a point of view presented by this research by focusing on the role of mathematics or smart mathematical programs to enhance the flexibility of architecture production towards the future.

Illustrative example:

A project with a known and limited capacity, let it be 2000 visitors. The number of visitors cannot exceed 3,000, because at the end, the project is not of welfare because it is a project with a specific capacity, a specific standard, and a specific area. Smart sports programs are relied upon to know the space of every visitor. These programs calculate the structure and space for each person, so the result is represented in several cases:

- If the standard is increasing, the research will suggest a trend towards increase.
- If the standard is decreasing, then the research will suggest a trend towards slimming.
- If the standard indicates the existence of a defect, the research will suggest a trend towards developing appropriate solutions and treatments to obtain higher adaptation.

These applied mathematical smart programs are what the research seeks to rely on to achieve flexibility for a better future for architecture.

Results

- Flexibility is a feature that enables us to make modifications in the spatial or functional structural system of the origin or structural flexibility. The ability to make changes and rebuild the system at all levels is made possible by this flexibility characteristic, which also enables ongoing usage of the facility at a high level for the shortest amount of time. This helps in achieving continuity and complete harmony with the changing structural and environmental functional requirements, taking into account achieving flexibility throughout the life of the building while providing the possibility of modification or change in the design stages with performance evaluation of the construction process, which can be obtained through applied mathematical intelligence. This evaluation also requires a new dynamic for the structure to appear balanced and integrated in its various stages, whether before or after the change.
- Flexibility requires designers with flexible thinking who are able to transform and qualitatively move between situations while seeing problems from many angles and the ability to find solutions adaptively, appropriately and efficiently.
- Architectural production acquires the characteristic of flexibility when adapted to expected changes and meeting the largest amount of needs with the ability to respond to the needs of the present and expected changes in the future through the optimal use of new technologies and available materials. Therefore, solutions were available with the ability to make modifications and additions.
- Creating a flexible, livable environment compatible with changes and shifts in needs and changes in jobs. The designer is supposed to take advantage of the recent developments of technology with an orientation to consolidate the principles of flexibility for a better future for architecture. This provides frameworks to support new

paths of creation, manufacturing, design, and the development of flexible applications with features that make their development and design easier, faster, and more appropriate for future developments while responding to the growing demands of a dynamic society. It is necessary to move towards more flexibility for the architecture of the future to meet the environmental, economic and societal challenges, in order to achieve greater compatibility with possible future developments. That this flexibility occupies a better position in future architecture perceptions. This led to the pursuit of presenting descriptive analytical studies on the principles of flexibility in architecture and its applications.

- Flexibility in architecture is of great importance, especially in housing, where its importance emerges from an economic point of view for families with limited income, because their needs are increasing, changing and continuous. Instead of exhausting them financially by changing housing to another housing that meets their needs, we make their housing highly flexible because it can be modified by extending its life span while limiting waste in environmental data.
- To achieve flexibility in architecture, it must be studied in the design, implementation and even in working phases. The role of the architect in achieving them is added to the role of the user, as he is better acquainted with his changing needs.
- It is possible to make modifications for the building during the working stage by choosing a flexible structural system (from a structural point of view) and relying on an efficient method in forming architectural spaces with the possibility of modifying it in a flexible way in the future (from a functional point of view).

Recommendations

- The research recommends using flexibility in mathematical analysis and artificial intelligence to detect changes in mathematical relationships in order to predict or sense the future urban situation and thus make the flexible design decision that will be appropriate to that.
- Directing architectural studies towards predicting the type or nature of future functional activities according to which the design is made. The study is directed by adopting the principle of flexibility that benefits future architecture by introducing modern mathematical trends that are more predictive of future functional needs. This is done through digital programs that review the condition of multiple buildings, for example, during several periods, in order to reach the need of each person according to the square meters, according to which we reach the human need in its state of increase or decrease towards luxury.

References

Abdel-Gawad, T, A. (1977) Giants of Architecture in the 20th Century. First edition. Cairo: Anglo Egyptian Bookshop.

M. Lourens, A. Tamizhselvi, B. Goswami, J. Alanya-Beltran, M. Aarif and D. Gangodkar, "Database Management Difficulties in the Internet of Things," 2022 5th International Conference on Contemporary Computing and Informatics (IC3I), Uttar Pradesh, India, 2022, pp. 322-326, doi: 10.1109/IC3I56241.2022.10072614.

Abd Algani, Y. M., Caro, O. J. M., Bravo, L. M. R., Kaur, C., Al Ansari, M. S., & Bala, B. K. (2023). Leaf disease identification and classification using optimized deep learning. Measurement: Sensors, 25, 100643.

Acharya, L. (2013) Flexible architecture for the dynamic societies. Reflection on a Journey from the 20th Century into the Future, Master's thesis in Art History, Faculty of Humanities, Social Sciences and Education, University of Tromsø.

Abd Algani, Y. M., Ritonga, M., Kiran Bala, B., Al Ansari, M. S., Badr, M., & Taloba, A. I. (2022). Machine learning in health condition check-up: An approach using Breiman's random forest algorithm. Measurement: Sensors, 23, 100406. https://doi.org/10.1016/j.measen.2022.100406

Mourad, H. M., Kaur, D., & Aarif, M. (2020). Challenges Faced by Big Data and Its Orientation in the Field of Business Marketing. International Journal of Mechanical and Production Engineering Research and Development (IJMPERD), 10(3), 8091-8102.

Al-Akyabi, M, A.& Hassan, N, M. (2002) Features of Design Thought for Heritage Architecture (A Study on the Possibility of Application in New Desert Areas), research published in: Seminar on Urban Development in Desert Areas and Building Problems, Ministry of Public Works and Housing, Riyadh.

Naidu, K. B., Prasad, B. R., Hassen, S. M., Kaur, C., Al Ansari, M. S., Vinod, R., ... & Bala, B. K. (2022). Analysis of Hadoop log file in an environment for dynamic detection of threats using machine learning. Measurement: Sensors, 24, 100545.

Sharma, Nisha, Anil Kumar Yadava, Mohd Aarif, Harishchander Anandaram, Ali Alalmai, and Chandradeep Singh. "Business Opportunities And Challenges For Women In The Travel And Tourism Industry During Pandemics Covid-19." Journal of Positive School Psychology (2022): 897-903.

Alaraji, K. & Mahmud, M, Jusan (2012) Flexible Architectural Design And User Participation. Architecture in the Faculty of Built Environment at Universiti Teknologi Malaysia

Al-Bajari, F. (2008) Flexibility in Architectural Design - A Case Study of Second Cycle Schools in the Syrian Arab Republic" Department of Architectural Design. Master's thesis, Faculty of Architectural Engineering, Damascus University, Syrian Arab Republic.

Bosco Ekka, Dr G., Dr Prince Verma, and Dr Harishchander Anandaram. "A Review Of The Contribution Of Youth To Sustainable Development And The Consequences Of This Contribution." Journal of Positive School Psychology (2022): 3564-3574.

Aarif, Mohd. "A Review Of The Contribution Of Youth To Sustainable Development And The Consequences Of This Contribution." Journal of Positive School Psychology http://journalppw. com 6, no. 6 (2022): 3564-3574.

Yadava, Anil Kumar, Irfan Ahmed Khan, Prashant Pandey, Mohd Aarif, Gaurav Khanna, and Shaifali Garg. "Impact of marketing communication and information sharing on the productivity of India's small and medium-sized businesses (SMEs)." International Journal of Health Sciences 6 (2022): 12745-12755.

Al-Mahdi, D, (2015) A New Look at Architecture Chaos in the Framework of (Organized Chaos), Article Four, Volume Five, Issue 9.

Ana, M, & Safiullah and Zeba Nisar (2017) Flexible Architecture: Optimization of Technology and Creativity. International Journal of Engineering and Technology (IJET), Vol 9 No 3S

ESTAJI, H. (2017). A review of flexibility and adaptability in housing design. International Journal of Contemporary Architecture, The New ARCH, 4, (2), 37-49.

Hassan, N, M. (2001) Architecture Theories - 2", the author's publishing house, Assiut, Arab Republic of Egypt.

Hassan, N, M.(2005) Values of Creativity in Architectural Design. Technology Journal, Ministry of Municipal and Rural Affairs, Riyadh, Issue 6.

Inani , S. & Kumar, A. (2012) Flexibility Concept in Design and Construction for Domestic Transformation, CSIR- Central Building Research Institute, Roorkee, Roorkee, Uttarakhand, India

Kandavalli, S. R., Wang, Q., Ebrahimi, M., Gode, C., Djavanroodi, F., Attarilar, S., & Liu, S. (2021). A brief review on the evolution of metallic dental implants: history, design, and application. Frontiers in Materials, 140.

Ruban, S. R., Jayaseelan, P., Suresh, M., & RatnaKandavalli, S. (2020, December). Effect of textures on machining of carbon steel under dry cutting condition. In IOP Conference Series: Materials Science and Engineering (Vol. 993, No. 1, p. 012143). IOP Publishing.

Naidu, K. B., Prasad, B. R., Hassen, S. M., Kaur, C., Al Ansari, M. S., Vinod, R., ... & Bala, B. K. (2022). Analysis of Hadoop log file in an environment for dynamic detection of threats using machine learning. Measurement: Sensors, 24, 100545.

Suman, P., Bannaravuri, P. K., Baburao, G., Kandavalli, S. R., Alam, S., ShanthiRaju, M., & Pulisheru, K. S. (2021). Integrity on properties of Cu-based composites with the addition of reinforcement: A review. Materials Today: Proceedings, 47, 6609-6613.

Kandavalli, S. R., Rao, G. B., Bannaravuri, P. K., Rajam, M. M. K., Kandavalli, S. R., & Ruban, S. R. (2021). Surface strengthening of aluminium alloys/composites by laser applications: A comprehensive review. Materials Today: Proceedings, 47, 6919-6925.

Sharma, Nisha, Anil Kumar Yadava, Mohd Aarif, Harishchander Anandaram, Ali Alalmai, and Chandradeep Singh. "Business Opportunities And Challenges For Women In The Travel And Tourism Industry During Pandemics Covid-19." Journal of Positive School Psychology (2022): 897-903.

Raja, R., Jegathambal, P., Jannet, S., Thanckachan, T., Paul, C. G., Reji, S., & Ratna, K. S. (2020, November). Fabrication and study of Al6061-T6 reinforced with TiO2 nanoparticles by the process of friction stir processing. In AIP Conference Proceedings (Vol. 2270, No. 1, p. 030002). AIP Publishing LLC.

Kumar, B., & Kumar, P. (2022). Preparation of hybrid reinforced aluminium metal matrix composite by using ZrB2: A systematic review. Materials Today: Proceedings.

Alalmai, Ali A., Gulnaz Fatma, A. Arun, and Mohd Aarif. "Significance and Challenges of Online Education during and After Covid-19." Turkish Journal of Physiotherapy and Rehabilitation 32, no. 2.

Tripathi, Mano Ashish, Ravindra Tripathi, Navneet Sharma, Surabhi Singhal, Muskan Jindal, and Mohd Aarif. "A brief study on entrepreneurship and its classification." International Journal of Health Sciences 6 (2022).

Kandavalli, S. R., Khan, A. M., Iqbal, A., Jamil, M., Abbas, S., Laghari, R. A., & Cheok, Q. (2023). Application of sophisticated sensors to advance the monitoring of machining processes: analysis and holistic review. The International Journal of Advanced Manufacturing Technology, 1-26.

Aarif, Mohd, and Ali Alalmai. "Importance of Effective Business Communication for promoting and developing Hospitality Industry in Saudi Arabia." A case study of Gizan (Jazan) (2019).

Aarif, Mohd. "A STUDY ON THE ROLE OF HEALTHCARE INDUSTRY IN THE PROMOTING OF HEALTH TOURISM IN INDIA." A CASE STUDY OF DELHI-NCR (2018).

Khuzam, H. (2009) A feasibility study and prospects for limited-space housing in Syria", Department of Architectural Design. PhD thesis, Faculty of Architecture, Al-Baath University, Homs, Syrian Arab Republic. p. 307.

Kim , Y. (2008) Organism of Options: A Design Strategy for Flexible Space. Master of Architecture at the Massachusetts Institute of Technology.

Marcin G. (2019) Sustainable and creative temporary architecture: the activities of the assemble collective, Technical Transactions, Architecture and Urban Planning, Cracow University of Technology.

Morsi, M. The role of flexibility in the design of furniture systems and metal construction, published research, Journal of Science and Arts Studies and Research, Helwan University, Cairo, Volume Fifteen, Issue Four.

Mustafa, S. (1979) A Look at European Architecture. Arab Renaissance House, Beirut, first edition.

Oxford English Dictionary Online, 2011.

Prins, M. (1992) The Management of Building Flexibility in The Design Process: a design Decision Supports Model for Optimization of Building Flexibility in Relation to Life Cycle Costs in: Nicholson, M.P., Architectural Management, 1st Edition, E & FN Spon, London.

Shirzad, S, E. (1999) Modern Architectural Movements, International Style in Architecture. First Edition. Beirut: The Arab Institute for Studies and Publishing.

Tannous, W, & Al-Muhanna, Fakush. O. (2013) Design flexibility as one of the most important criteria for economic housing. published research, Damascus University Journal of Engineering Sciences, Syria, Volume 29, Issue 1.