

Local Kinetic Architecture to develop Egypt's Housing spaces

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Abstract- As the world evolves and changes, the requirements and needs of users in buildings change, and thus the needs of the population in Egypt are changing, so it has become necessary to resort to innovative solutions that keep pace with the times, and one of the most important features of kinetic architecture is that it keeps pace with development and is flexible in use, and therefore it is the best solution Architectural problems in this era.

The paper discusses an approach to develop housing in Egypt through kinetic architecture with local tools, to meet the changing needs of the population, among these needs, physical needs such as the desire to increase the housing area, or change the vision, or provide light, thermal and air comfort in different seasons, and the needs of users may be non-physical, such as the desire to change and try something new for the dwelling, or to show off, so kinetic architecture works to provide different solutions to meet these changing needs to keep pace with the permanent changes faced by contemporary society, Where kinetic architecture can be used to enhance the aesthetic characteristics of the building or to interact with environmental conditions or Implementation of functions that are difficult to achieve fixed construction.

In this paper A proposed unit is presented as one of the solutions which users can be provided with additional space that can be used according to their needs, using the kinetic architecture.

Index Terms- Local Kinetic Architecture, Mechanism, Motion, Housing, Extra space

I. INTRODUCTION

In recent years, a trend has emerged that calls for looking at the building as a structure in a state of dynamic equilibrium and not as a traditional structure in static equilibrium. And how to change the course of human life and make it shorten the time and effort in the buildings in which the person lives and exercises his life functions.

The rapid development in various social, economic, and technological fields is changing the lifestyle, behaviors, habits, and daily needs of people at the same rate. Accordingly, our expectations are constantly changing from the spaces in which we carry out various activities. As the buildings are initially designed for specific purposes and needs do not provide the expected functionality after a while with the continuous changes of users' requirements. With the flexibility available in architectural design, buildings must be transformable and changeable after the design is completed

I. KINETIC ARCHITECTURE

Kinetic architecture is a product of the development of architecture through the ages, where architecture is transferred from a fixed form to a moving one and the transition from boredom and monotony to vitality and change. Buildings go back to ancient times and were represented in the movement of doors and windows and the movement of bridges in castles and fortresses that were used for defensive purposes, then witnessed a great development with time, from manual systems to mechanical and then to electronic and smart systems and became more and more diverse in use.

The main reason for building any architectural facility is to achieve the goal of the users and meet their physical and non-physical needs, and thus the architectural spaces of this facility become successful. kinetic architecture provides solutions and ideas that can keep pace with the constantly changing needs of users.

A. Kinetic Architecture objectives

kinetic architecture must meet the needs of the user in perceiving the pleasure and savoring the formal beauty as well as the function. The intended use of movement in architecture varies according to usual conditions and requirements. As the main motive for the trend towards kinetic architecture is the need for comfort, flexibility and the ability to change the shape, and the uses of kinetic architecture can be classified into functional, formative, environmental and economic uses **fig(1)**.

The functional objectives divide into Flexibility in achieving various functions which depend on equipping spaces with mechanisms that allow spaces to be transformed into a limited number of spatial variations to serve a specific number of tasks, Harmony with Environment as There are times when people benefit from or avoid nature such as climate change, daily weather conditions, sun, wind, Location change & various views due to the need to change the location in the building[1], Space increasing as The expandable, shrinkable, open and closed surfaces are designed to increase the versatility of spaces, so space shapes can be changed to suit different functions[2]. Formative objectives as One of the most important effects that the movement achieves for construction while gaining a new dimension through the architectural movement is to change the aesthetic perception and create a mind-blowing appearance for the users. Where changing kinetic shapes and structural formations leads to different feelings for people. Economic objectives that kinetic buildings could reduce energy waste by using kinetic elements allow the building to be adapted with the weather, also kinetic buildings could be a landmark attract income [3].

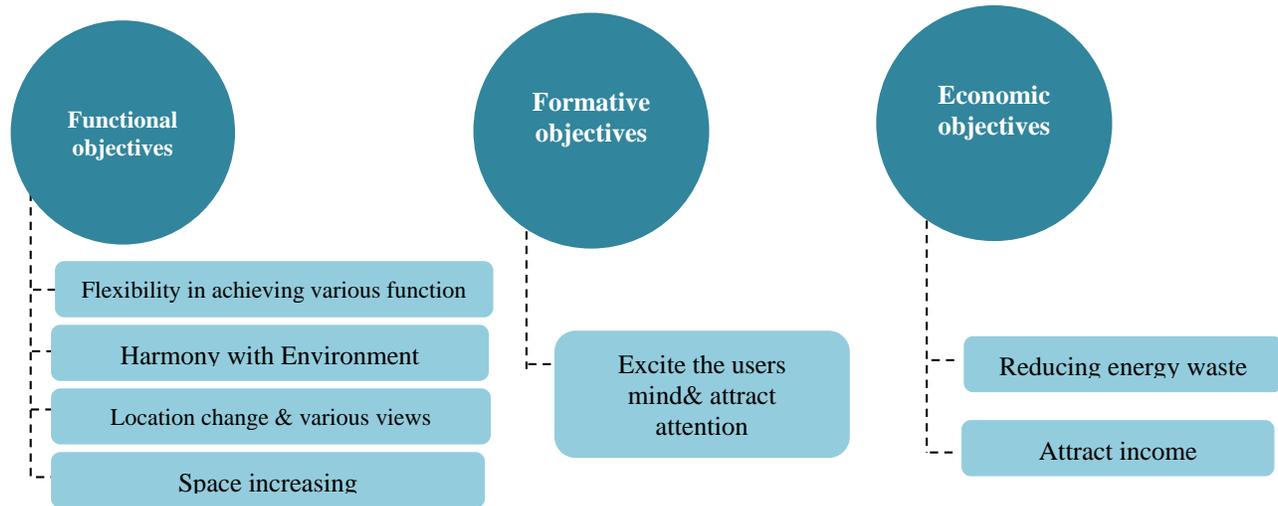


Figure 1 objectives of kinetic architecture, source: the researcher

II. HOUSING & USERS RESPONSES

It is the shelter that includes the individual and the family and the nucleus of stability in its comprehensive sense, which is a prerequisite for human giving in its sensory and intellectual dimensions. Hence the importance and value of housing for the individual and society. [4] Also, it is the place where a person satisfies a large part of his physical, non-physical needs and it's a source of health safety.[5]the dwelling is also the container that expresses the degree of transformation in the personality of the one who inhabits it.[6]

A. Behavioral responses of housing spaces users

First: human behavior

It is the adaptation between an individual and his environment.[7] also, It is any action by which a living organism responds to a situation and the response depends on its previous experiences.[8]

As behind every human behavior is a motive, and behind every motive is a desire, and the motive refers to an internal state that results from a need, and this state activates the behavior towards achieving the desired need.

Second: the response of users to the design of architectural spaces

The response of users to the design of architectural spaces varies, and it is divided into three categories [9] as shown **fig 2**:

- Give up to the space and interact with it.
- Attempting to modify the space to suit the needs of the population.
- Not interacting with the space and the abandonment of users to it.

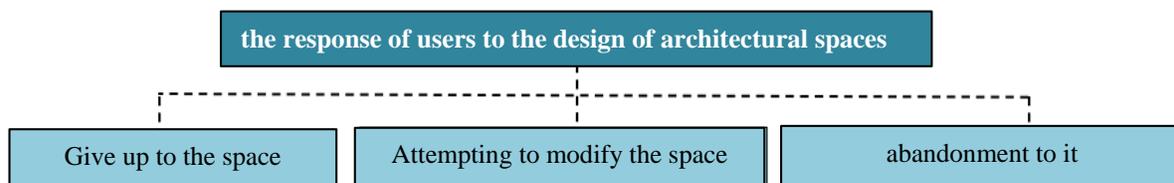


Figure 2 the response of users to the design of architectural spaces, source: the researcher

From here, the designer had a great role in understanding the human needs within the space, and how the person accommodates the formations of the surrounding residential spaces that should meet the purpose assigned to them [10].

III. THE KINETIC PROPOSED DESIGN

A. Design concept for proposed unit

Through the kinetic architecture, the room is provided with an additional area of up to 6 m² that allows the user to use it according to the needs to be achieved.

- The dimensions of the original room is (3 m * 4 m)
- Dimensions of the additional space provided by the mobile model is (2 m * 3 m) **fig (3)**

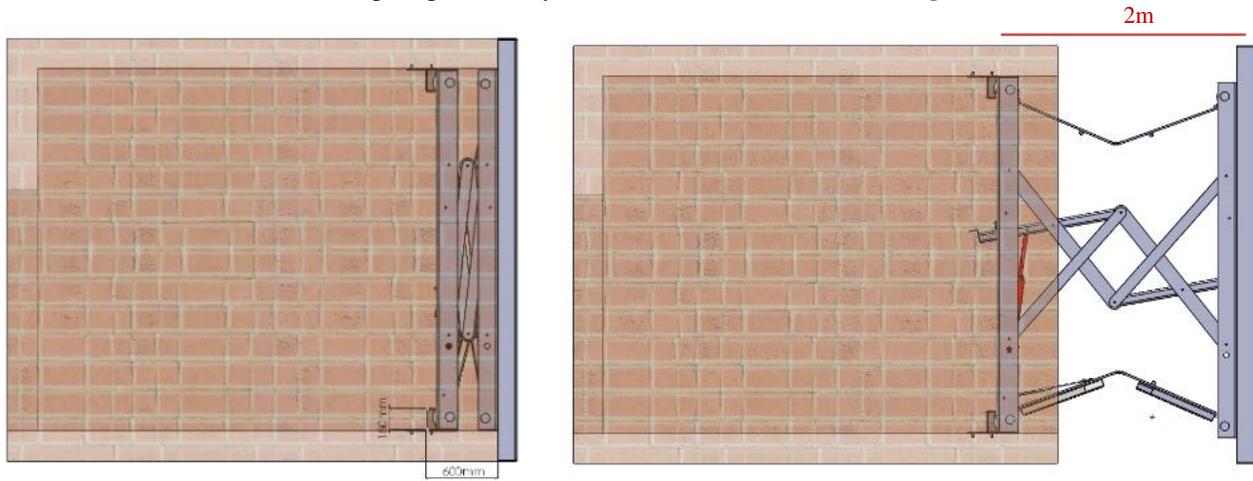


Figure 3 proposed kinetic design of extension 2m length ,3m width, source: the researcher

The additional space could be used by the users as a terrace or, for adding extra bed to the room or, for a certain activity **fig (4)**



Figure 4 different uses for the kinetic space, source: the researcher

B. Formation concept for proposed unit

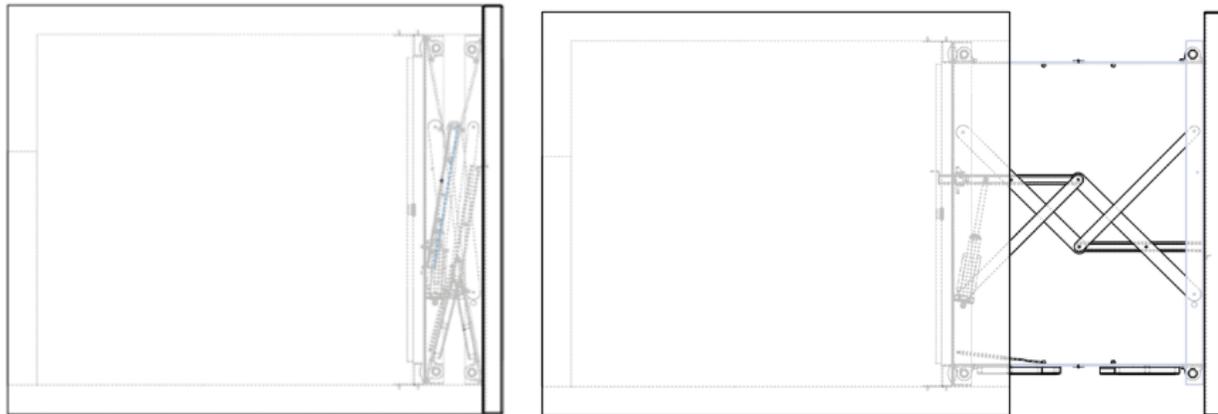
The unit gives an aesthetic shape to the external facade, giving a diversity and difference to the facades when using more than one unit, but in an organized and designed way. Where it is possible to install more than one unit for the building and paint the units in consistent colors, which gives and attracts attention to residential buildings in Egypt.



Figure 5 expected façade by using the kinetic model, source: the researcher

C. Structure of the proposed unit

The unit consists of a foldable system consisting of three basic connecting parts, and a steel base, working to provide an open and closed space as in the shape.



6 Proposed mechanism of the kinetic model, source: the researcher

Figure

- The total mechanism weighs about 5 tons therefore, the room must withstand this additional load.
- The load on which the loads were calculated is 450 kg per square meter, according to the calculations of live and dead loads.

Structural components can be determined to fail by various modes determined by buckling, deflection, natural frequency, strain, or stress. Strain or stress failure criteria are different depending on whether they are considered as brittle or ductile materials. The difference between brittle and ductile material behaviors is determined by their response to the loads **fig (7)**.

Here, a Von Mises stress energy failure theory is used to test our material and to detect the possible deflection that can be occurred due to the applied load using SOLIDWORKS software. AISI 304 is the main material of the various parts of the mechanism which its yield strength is about 2.068×10^8 .

The following figures will indicate the stress analysis and the deformation on the different parts of the mechanism. The total mechanism approximately weights 5 ton so, the room must sustain this additional load.

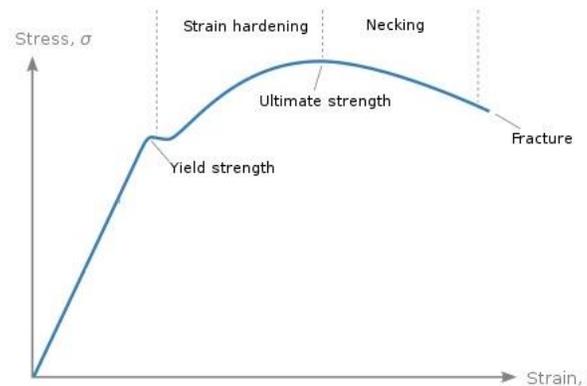


Figure 7 the phases of the reaction of a (Mild steel) starting from the flexibility stage, then plastic, then the hard strain, stage where the increase in the resistance of the material and then the stage of collapse, source: Courtney, Thomas (2005). Mechanical behavior of materials.

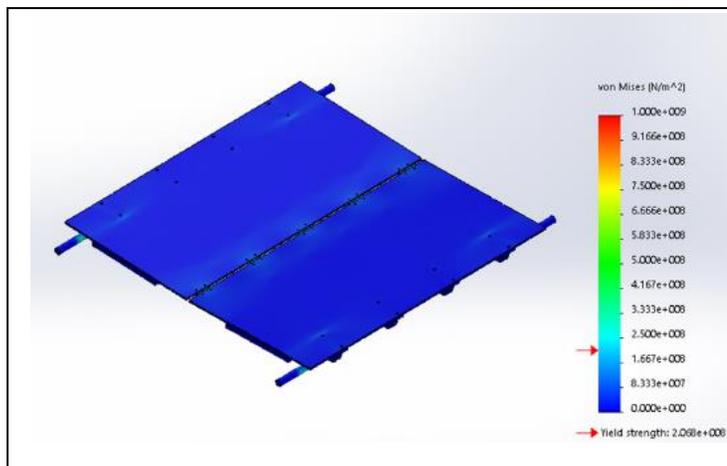


Figure 8 Stress analysis of the kinetic unit base
 source: the researcher

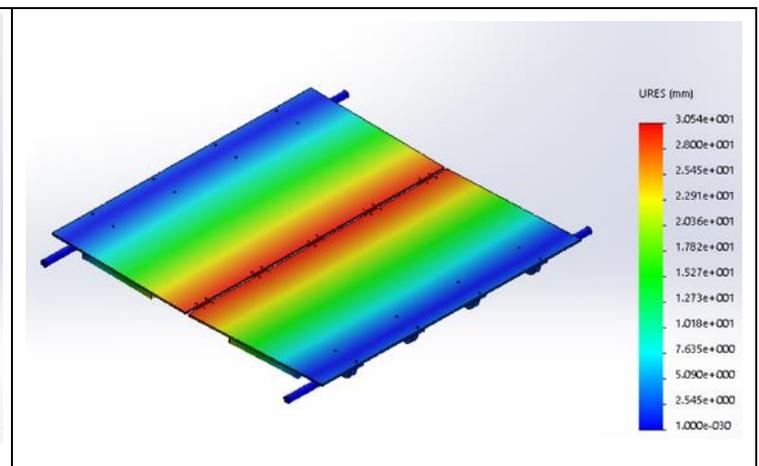


Figure 9 Deflection of the kinetic unit base
 source: the researcher

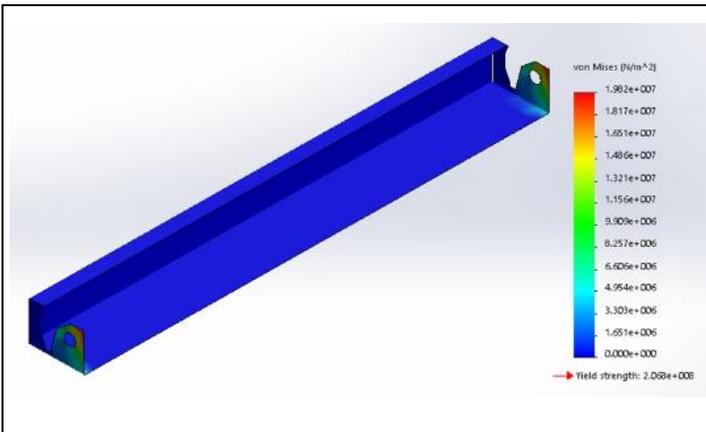


Figure 10 Stress analysis of the kinetic unit fixed base
 source: the researcher

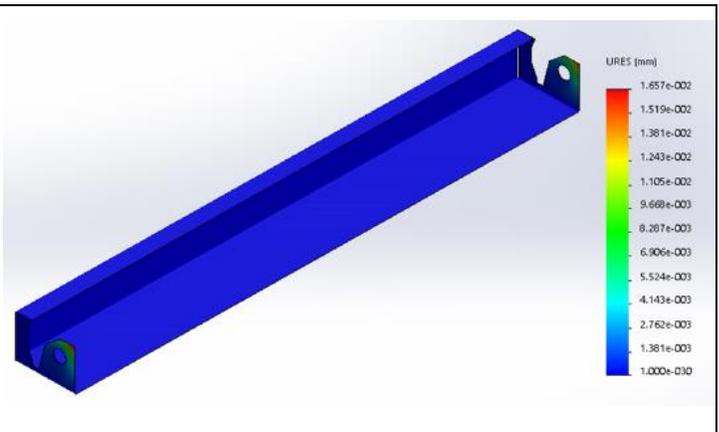


Figure 11 Deformation of the kinetic unit fixed base
 source: the researcher

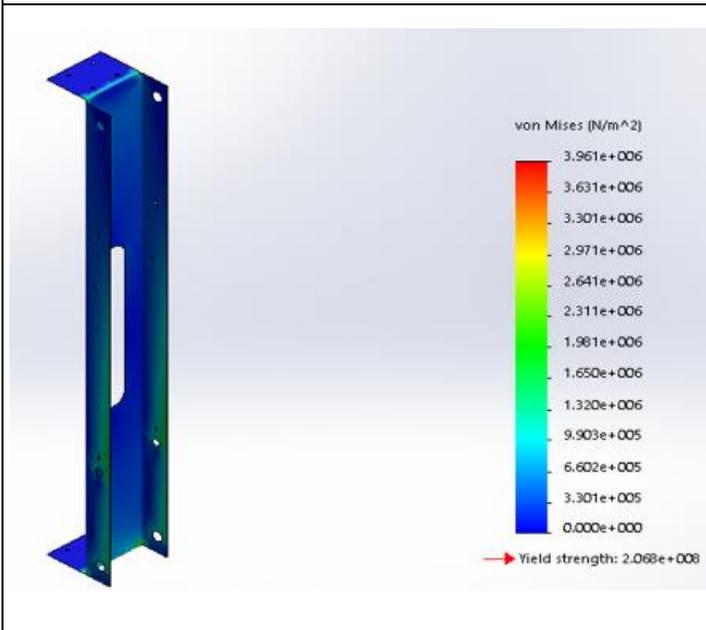


Figure 12 Stress analysis of the mechanism holder
 source: the researcher

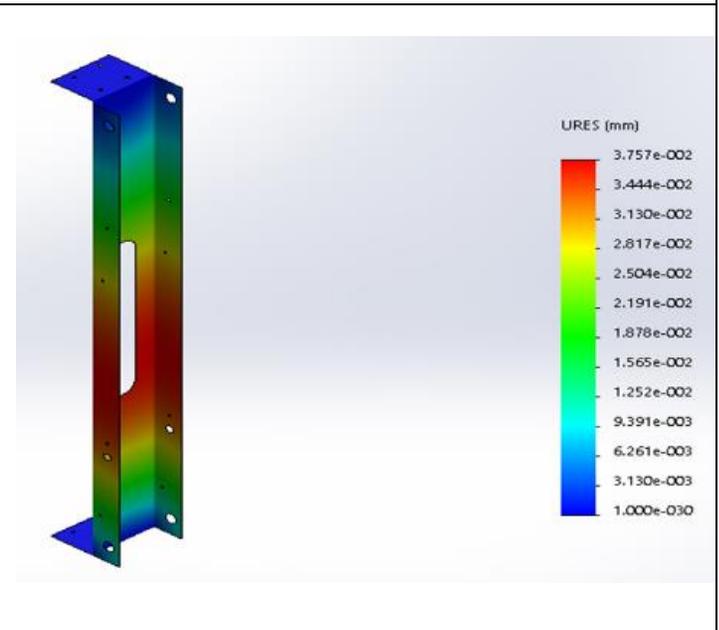


Figure 13 Deformation of the mechanism holder
 source: the researcher

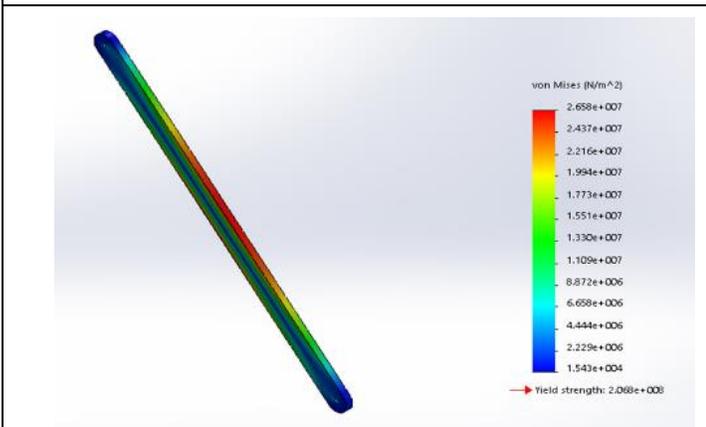


Figure 14 Stress analysis for link 1
 source: the researcher

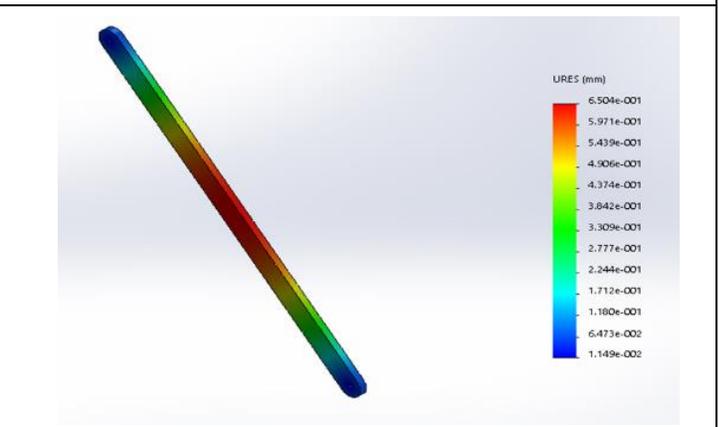


Figure 15 Deformation of link 1
 source: the researcher

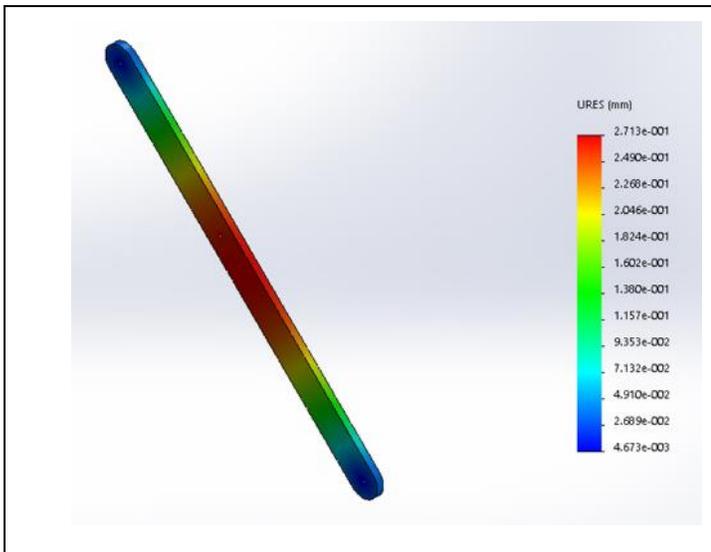


Figure 16 Stress analysis for link2
 source: the researcher

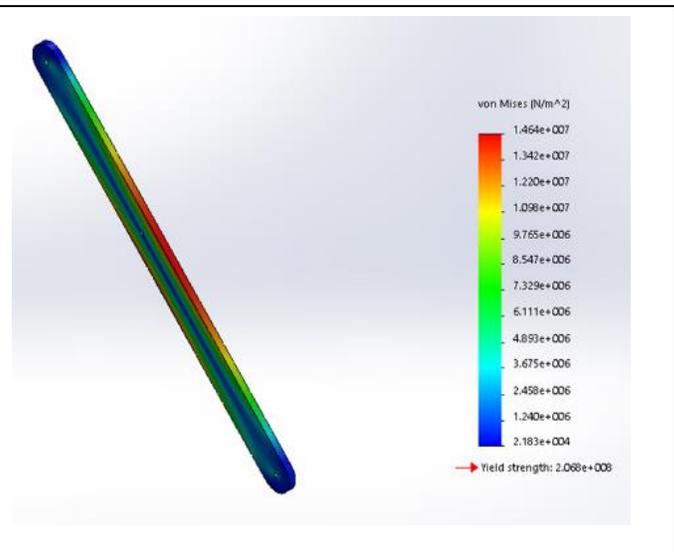


Figure 17 Deformation of link2
 source: the researcher

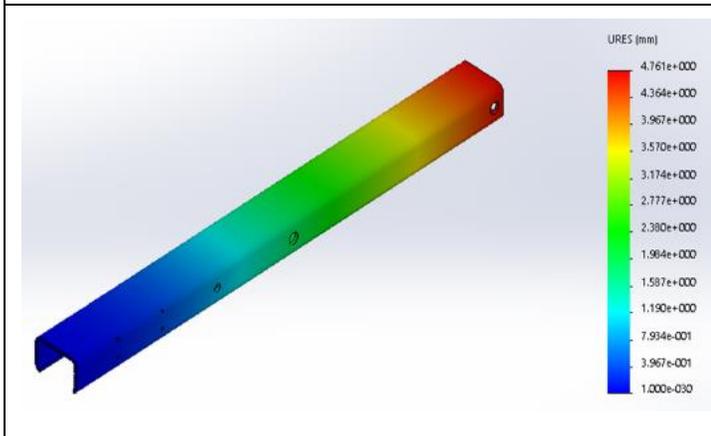


Figure 18 Stress analysis for link3
 source: the researcher

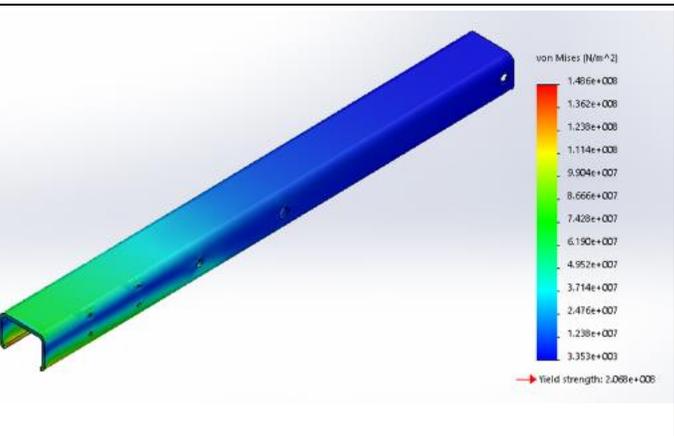


Figure 19 Deformation of link3
 source: the researcher

D. Automation Technology of proposed unit
Working Theory

- This mechanism operates manually when the user moves the hand of the pump down, it gradually pushes link3 up, then all the mechanism opens to 2 meters as shown **fig (20)**.
- To close the mechanism all the user should do is to rotate the release button of the pump, the mechanism will return back to the closed state.
- This mechanism consists of three main categories Which are: source of movement, movement supporters, Movable body.
- First category is source of movement in the mechanism is the pump which provide the main motion, second the movement supporters consist of Lift supports, radial ball bearing, Hinges, Latch. last category is the movable body which contain the links, base, ceiling, and elevation as shown **fig (21)**.

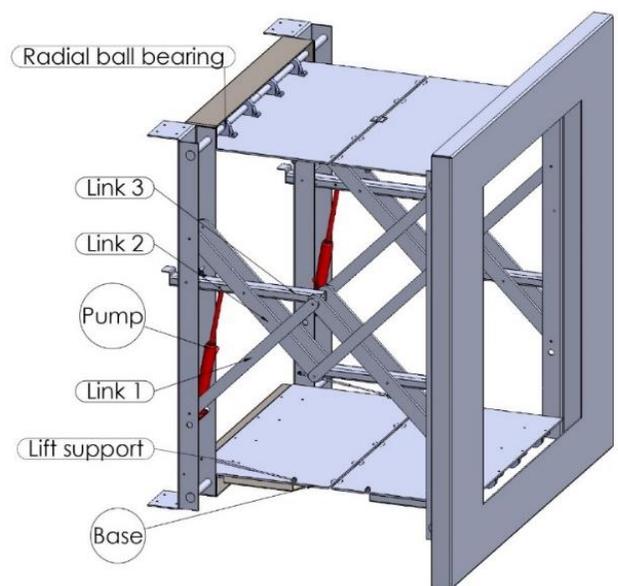


Figure 20 Elements of the kinetic mechanism
 source: the researcher

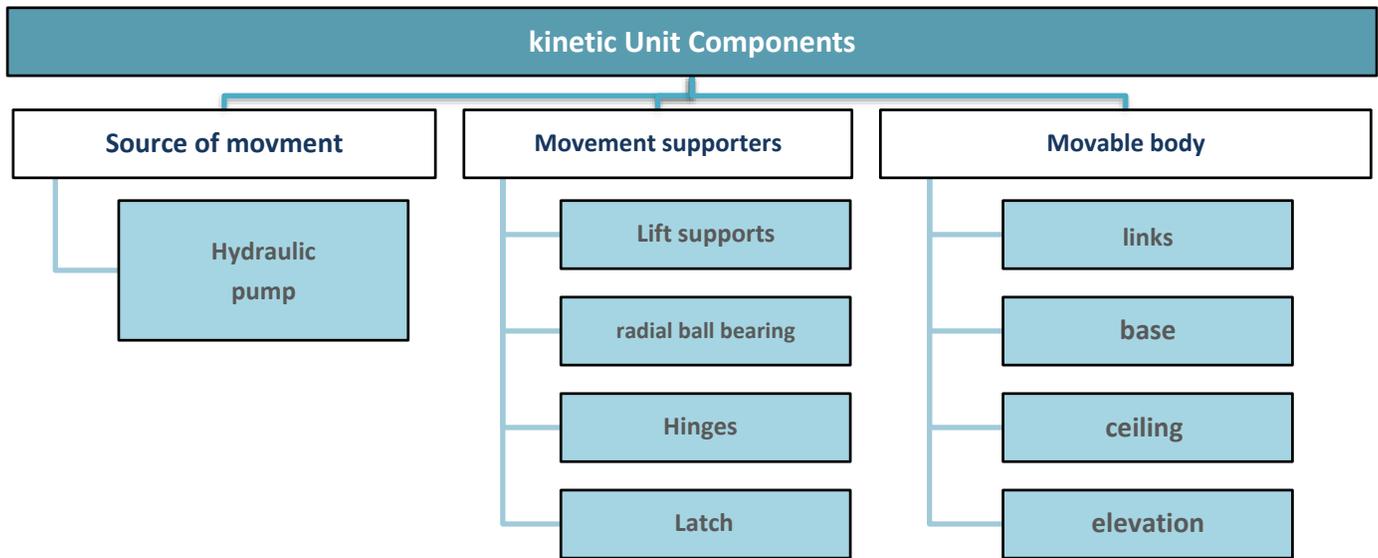


Figure21 kinetic unit components , source: the researcher

As shown in **Table 1** components of the proposed mechanism and its function, description, and quantity needed of each component.

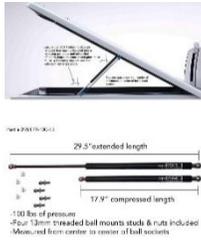
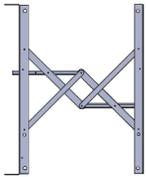
Components	Hydraulic pump	Lift supports	radial ball bearing	Hinges	Latch	links
Function	provides the main motion	supports the folded base	deals with the radial loads and allows the base rotation	assemble the two parts of the base and allow the base rotation	locking the mechanism when it is fully opened	provide the opening of the foldable room.
Product description	The Torin BIG RED T30806 hydraulic long ram jack has a single piston pump and clevis base that is designed for residential and commercial use.	Truck Up fitters Pair (2 total) of 100-pound (each) gas struts. 29.5" extended length and 17.95 compressed length.	The SKF P2BL-FM pillow block bearing has a housing made of cast iron with two mounting bolts, an eccentric locking collar, and contact seals.	High Quality Pair of Stainless Steel Plated 4 x 4 inches Square. Commercial Ball Bearing Hinges Satin Nickel.	Manufacture d from high quality, 304 series stainless steel this 2-way latch will not rust or corrode over time.	This mechanism consists of three main links assembled in a specific pattern to These links are made of AISI 304
Quantity needed	2	1 package hint: each package contains 2	4	4 packages hint: each package contains 2	4	-
shape						

Table 1 kinetic unit components specification, source: the researcher

IV. IMPACT ON MAIN ARCHITECTURAL WORK

Every architectural work has an impact on the main aspects of architecture, whether it is a functional aspect, formative, structural, technological aspect. the shown **Table 2** represents the points that the proposed mechanism has an impact on it in the four main aspects of architectural work.

Impact of the kinetic model on architectural work aspects					
Impact on the architectural work aspects	Architectural work aspects		Description	Achieve	Not achieved
	Functional aspect	lighting	The appropriate distribution of lighting, whether it is natural or artificial lighting, and it is preferable to be natural.	✓	
		Thermal comfort & ventilation	Providing the necessary ventilation through the use of openings and the ability of the space to adapt to the seasons of the year.	✓	
		privacy	The possibility of controlling the opening or closing of the building in relation to the outside.	✓	
		Security& safety	The use of security and safety factors in the building and thus achieve safety	✓	
		Flexibility in achieving various function	Flexibility of space to adapt to the functions to be achieved according to the users.	✓	
		Change of views/ spatial diversity	Providing various viewing angles for the building without moving it.	✓	
	Formative aspect	Harmony with physical Environment	The shape of the building matches the surrounding environment.		✓
		Rhythm	Consisting of repeating masses, shapes, colors, or levels.	✓	
		proportion Harmonious	Compatibility and harmony between the mass and some of it, as well as between the mass and its surroundings and its components.		✓
		openings	The ratio of openings and solids in blocks.	✓	
		Light & Shade	It results from forming masses, shapes, colors or levels.	✓	
		Diversity	Diversity in the use of blocks and shapes together to make a formation that attracts attention.	✓	
	Structural aspect	Stability	The use of a structural system that achieves stability and balance for the building	✓	
		Efficiency of materials	Use efficient materials to achieve the structural system.	✓	
		Economic efficiency of the construction system	Provide the amount of material in the structural system.	✓	
	Technology aspect	Control mechanisms	Evolution of the methods and control methods used in the building.	✓	
		Development of implementation Methods	The development of mechanisms and methods of implementation and construction through technology.	✓	
		Structural analysis & design techniques	The use of computer programs during the design and structural analysis process.	✓	
		Evolution of material technology	Using innovative smart materials in the building.	✓	

Table 2 Impact of the kinetic model on architectural work aspects, source: the researcher

I. CONCLUSION

The study adopts a developed method by kinetic architecture as an approach to fulfill user's needs by providing them with additional space, that can be used according to their changing needs, The proposed kinetic model provides the user with the right to control the additional space, whether by opening or closing it, according to his needs.

The kinetic model provides a different experience for users in the space. Using the proposed model Preserves the shape of the buildings when there is a need to add space without the need to close the balconies or distort the shape of buildings.

The kinetic model has an impact on many elements of the main aspects of architecture, as the possibility of controlling the opening or closing of the building in relation to the outside, which provide people to control lighting, Thermal comfort & ventilation according to people need. Also, the Diversity in the use of blocks and shapes together to make a formation that attracts attention.

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