

KINETIC BEHAVIOR, THE DYNAMIC POTENTIAL THROUGH ARCHITECTURE AND DESIGN

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ABSTRACT

Kinetic behavior is a progressive methodology in architecture and design that allows some parts to move by mechanics or sensors, without reducing the overall structural integrity. It's the dynamic approach that integrates the different aspects arranging the outlined design. This paper aims to study the impact of intelligent systems in the interior design to produce new structures for interior elements within the terms of varied patterns and shape. It reveals the emergence of kinetic systems as an adequate procedure and substantial function to rethink and reshape interior spaces through metamorphic design, mobility, and mechanisms. These systems are applied due to their transition to portray and shift either, through specific forms or materials to plan new interactive inhabited spaces. This paper dissects the changes affecting the function of interior spaces through the analysis and interpretation of some architectural projects adapting dynamic mobile systems on setting the state and the structure of the building. Additionally, the main criteria pertaining the design to achieve further responsive potential, that is more engaged to the recipient and the environmental surroundings. Finally, the paper discusses the results of implementing canny dynamic systems and kinetic mechanisms to the elements of interior design tending how they can rapidly modify their function and regulate the performance and the efficiency and how to apply this methodology to reshape interior spaces.

Keywords: *dynamic interfaces, forms finding, interactive structures, kinetic architecture, materials, mechanisms, responsive design.*

1 INTRODUCTION

The ascending architectural thought stands at the threshold of a new evolutionary development. Charles Darwin has suggested that the problem of survival always depends on the body's ability to adapt to a changing environment [1]. This theory interprets the evolution dynamic behavior. Kinetic design arises from the isomorphic convergence between structure, function and responsive implications of interactive design to create dynamic, flexible perspective through a detailed adaptive multifunctional design constantly changing according to the users' needs. The advancement of adaptive design techniques and high-performance architectural solutions are required to achieve kinetic potential and mobility in the structure. Lately, there has been a growing interest in kinetic design and intelligent mechanical frameworks due to their consistent sustainment to carry out their functions and its constituents in a sustainable way.

2 REDEFINE DESIGN THROUGH VARIATION

Introducing an incipient approach to kinetic solutions in interior design, mechanisms that can be assembled and erected rapidly yet efficient and regularly applied. Aside, discovering the principles of kinetic interaction design through the implements of mobile patterns to engender dynamic forms, defining its main elements from structural innovation and materials advancement to embedded computation and adaptive architecture that have forsaken all that is traditional within the boundaries of the structure and the evolution of form and function, a cooperative relation to engender adaptable efficient, flexible spaces that respond to the requisites of any activity. The ability to adapt may range from multi-uses internal reorganization to complete transferability structure [2]. Kinetic behavior in structures allows

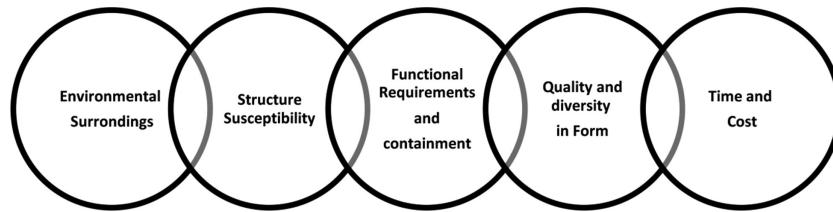


Figure 1: Illustrate the five fundamentals considerations in the detailed design process.

the elements in the built environment to subsist physically only when compulsory and disappear or transform when not needed. This suggests that the incipient dynamic aesthetic in the terms of form is rooted in a functional approach applied to the structure when the elements of the design can be displaced, changed, expanded, modified alternately or capable of dynamic movement.

A new generation of high-performance envelopes has contributed to the emergence of sophisticated assemblies combining real-time environmental response, advanced materials, dynamic automation with embedded microprocessors, wireless sensors and actuators, and design-for-manufacture techniques that has fundamentally transformed the way in which architects approach building design with a shift in emphasis from form to performance, from structure to envelope [3].

3 AIM AND OBJECTIVES

Technical design is the art of constructing and engendering buildings both functionally and aesthetically delectating. It's the ability to provide a conception through a detailed design process without losing the design purport. This study discusses the non-static kinetic structure, aside from the architectural responsive design infrastructure to the requisites and conditions of the space to develop a dynamic active, edifice invariably fluctuating using implemented mechanisms withal the widespread of technology evolution and its impact to adapt to the architecture towards the profound vicissitudes in the dynamic potential and how to re-design buildings responding to the ordinate dictations of modern society. This paper aims to demonstrate the efficacy of the application of kinetic design through mechanisms – methods in the design process to respond to the circumventing environment and interior spaces by applying a dynamic aspect.

4 KINETIC PRECEDENT

The principle is simple: no adjustment, no future. Adapt and survive. This introduced the kinetics concept, the main characteristics of kinetic architecture, which is in replication to the requirements of people or changing conditions. Kineticism is a concept, which refers the vicissitudes in the position of a “mobile building”. This reference designates that a building moves without any transmutations in its form. At the same time, kineticism provides the faculty of extension with cumulating of units of a “convertible structure”.

Different patterns in architecture and design can express the kinetic term in structural systems. The lifestyle of the nomadic people is transitory and the ease to engender a portable or interim shelter is one of the most predominant factors for their survival for thousands of years [4]. These forms are diverse and vary in patterns and details. They are classified into two main sectors, portable and demountable. In medieval times, open-air entertainments were popular all over Europe. In medieval times, Europe was popular by open-door entertainments. Plays were performed in demountable theaters, platforms or booths set up in the town

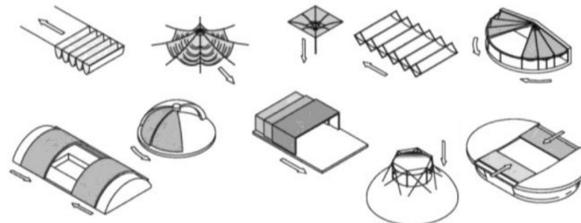


Figure 2: Various kinetic systems (Güçyeter 2004).

Rialto, or sometimes in a subsisting building [5]. Meanwhile, the buildings were covered with retractable roofs used as shelters against sun and rain.

Primitive forms of kinetic architecture such as the drawbridge can be traced back to the middle Ages or earlier. In the early period of the 20th century, designers started debating at a great scale the possibility of applying mechanisms and enabling mobility as a logical architectural solution, repudiates all theories supporting the stability of the buildings. The improvements in technology at the end of the 20th century have endorsed further applications of the assumption of extensibility in structural systems.

In 1970, William Zuk's book, kinetic architecture, was published. It inspired a new generation of designers to plan movable structures on an extended scale [1]. Assisted by new dynamic concepts and developments in robots, kinetic buildings become increasingly common in all parts of the world since the 1980s.

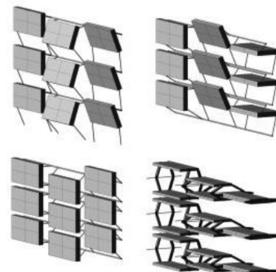


Figure 3: Kinetic pivoting façade panels.

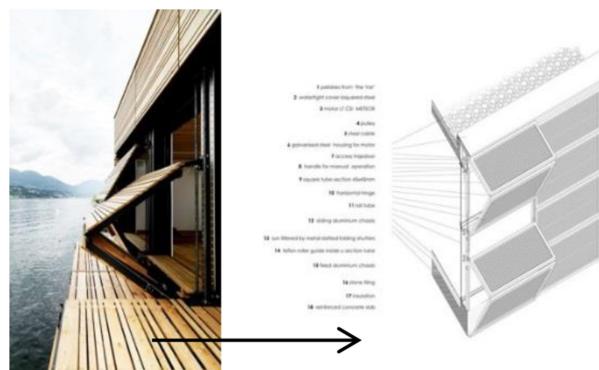


Figure 4, 5: Foldable /sliding façade mechanical panels.

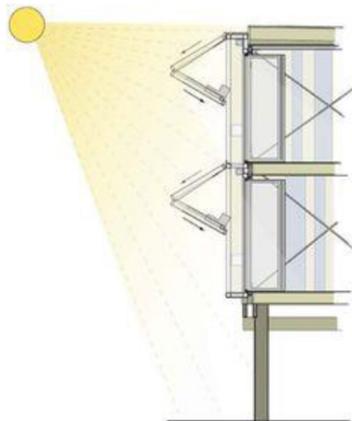


Figure 6: Façade responsive to daylight.

Foldable membrane structures designed with the development of high-strength fabrics. Sliding, folding or rotating mechanisms implanted in either the roofs, partitions or any part of a rigid structure, transfer and alter their shape, function, and even the used materials.

5 TOWARD A DEFINITION OF KINETIC ARCHITECTURE

The kinetic architecture refers to structures with perceived or genuine mobility in space and shifting ability to change geometrically. The pictorial and metamorphic bases are the principles of the kinetic terms approximately to integrate the fourth dimension, time to the design process, inciting the evolution of an adequate design applied to:

1. Enhance the design aesthetic peculiarities.
2. Respond to the surrounding environmental conditions and the recipient.
3. Perform functional tasks infeasible to be executed by a static structure.
4. Add the concept of a multi-functional design emerged which in reciprocation introduced solutions and treatments for narrow spaces.

The Kinetic design has conveyed a tremendous potential shown in the subtle elements, details, and patterns in its architectural features. It authorized the possibility of the integration of architecture and technology to designate an embryonic form of flexible, mobile and efficient structures. Consequently, the essence of such a design lies in the rules governing relationships and exhibiting auxiliary in both structure and materials establishing a detailed understanding analysis to obtain developing form modulated parametrically. Today, it is known as performance, which relates both to the material and its structural effort, depending on the shape of the form [6].

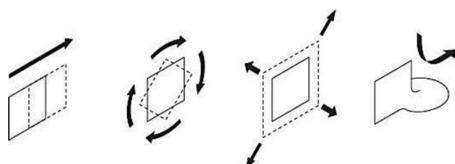


Figure 7: Definition of kinetic patterns through three geometric transformations in space – translation, rotation, scaling – and movement via material deformation.

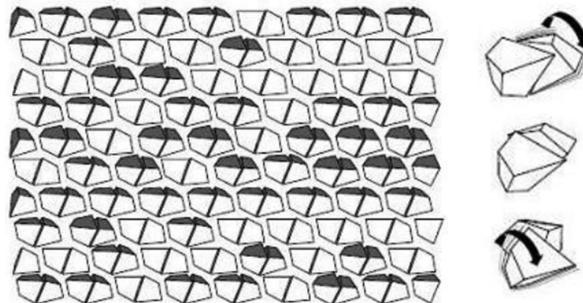


Figure 8: Analytical drawing of Flare.

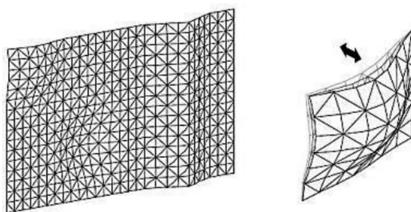


Figure 9: Analytical drawing of Aegis hypo surface façade prototype by WHITE Void, Berlin, 2008 by dECOi, Birmingham, UK, 1999–2001.

5.1 The anthology of kinetic structures

According to Cambridge Dictionary, a list of common-use words in the transformable architecture descriptions was explored and classified according to its definitions.

Comparative chart between terms	
To move	To arrange/to change
Deploy, Kinetic, Mobile, Portable, Transportable	Adaptable, Convertible, Develop, Expandable, Extendable, Flexible, Fold, Transform

5.2 Metamorphism design in form and function

Kinetic design and deployable mechanisms unveil the dynamic approach in interior spaces to change the traditional pattern in form and structure into interactive, responsive spaces providing its user the right to choose the scheme that fits the pattern of life and grants the potentiality of adjusting the passive pattern around him.

This architecture provides adaptability, identified by its simplicity, sophisticated designs, and demountable structures finished in several materials like wood, metals, polymers, textiles, and smart materials. It introduces the possibility of reconstructing and reshaping interior spaces and its components, while providing alternative economic solutions and a diversity of different perspectives and styles to various elements of architecture and interior design.

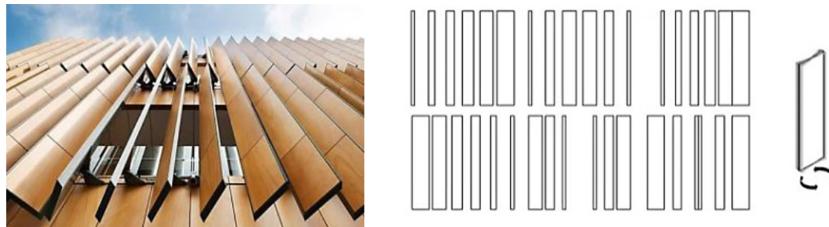


Figure 10: Illustrating rotating screens.

5.2.1. Soft forms of the buildings

Soft forms of the buildings possess the ability of conversion to respond to predetermined vicissitudes in the initial set of pressure. These buildings are capped with space enclosing resilient membranes made of layers of materials that convert by shoving, pushing or pulling. In this case, the alteration is linked to the material so that it doesn't matter where the transmutation occurs.

Conceptual design: - Interface screens with an umbrella-shaped foldable mechanism, each one opens by a central joint spring-loaded, allowing the users to open or close the shades to protect the glass façade and the interior from the sun in the summer and allow more light in during the winter. The idea is to make every umbrella controlled by the rotating movement of the mechanism to allow people to engage and respond to the building and the surrounding.

5.2.2. Rigid forms of building

Rigid forms of the building are those converted by sliding, folding or rotating structural elements of fine-tuned shape. These mechanisms are indistinguishable from the structure. Rigid kinetic structures consist of simple components connected by pivoting or sliding joints. When one part moves, the others move contingent to each other.

6 A NEW CONCEPT OF FORM IS INHERITED

Today, the rhythm of evolution is accelerated. Architecture is affected by this state of mutation in two ways. The first is the transmutation on the set of pressure, in a way that the forms react proportionately. The second is the development and advancement of technology that alters our ability to understand and interpret the constraints enabling the form to respond to felicitous changes. The first one is the typical static solution. In this case, the architect

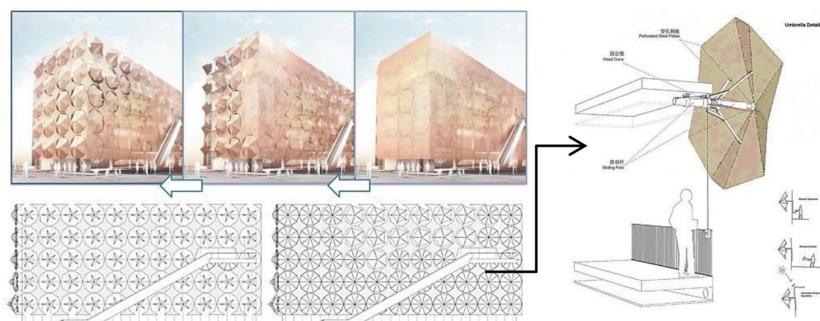


Figure 11, 12: Illustrating Umbrella façade, Shanghai expo 2010, China.

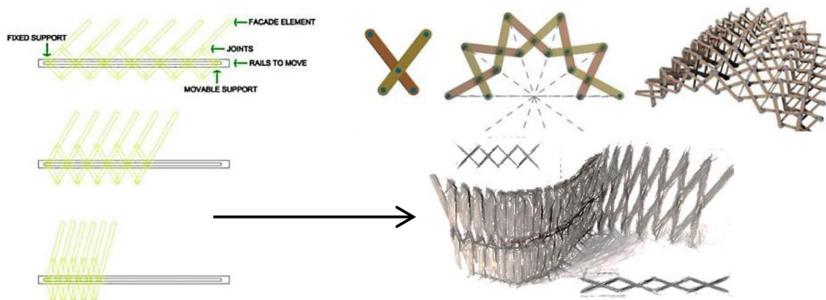


Figure 13, 14, 15: Retractable scissor mechanism covered with rigid plates.

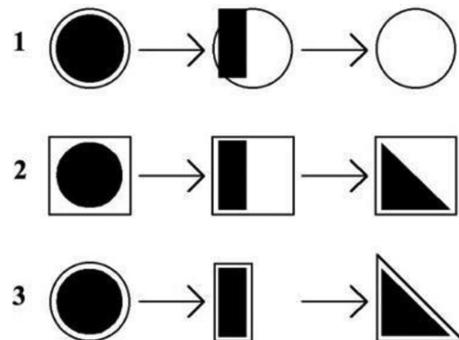


Figure 16: Three different conceptual approaches to the problem of change.

thinks about transmuting pressures and are either uncomfortably accommodated or physically sound building is remodeled or superseded. The second approach is represented best by Mies Van Der Rohe's principle of macrocosmic space. In this case, the architect plans a space to meet any functional demand. The buildings designed according to this method are not accustomed to any function. The ecumenical space solution as explored by Mies Van Der Rohe endeavors to solve all functions but very often authentically solves none. It is increasingly indispensable to develop a third conceptual approach, which will habituate to perpetual and expediting change. It is the kinetic architecture that apperceives the fluidity of the set of pressures to which the form must respond. In this state, space is enhanced to be flexible and impelled by the set of pressures to transform. A planar procedure to design compulsory when visualized that the structural form can be inherently displaceable, deformable, expandable, and in some other way capable of kinematic action.

6.1 Mechanisms

Mechanics is the science that follows physics, and it is one of the unlimited sciences dealing with the movement of objects and their causes. A branch of Mechanics is "Dynamics", which deals with objects under the effect of forces, which often follows statics study [7]. The purpose of adopting mechanisms is to change the design pattern of a static immobile system to a dynamic responsive structure through a united set of elements in an unprecedented consecutive configurations that fit the tangible functional requirements but rather, complement their use to the fullest extent using various styles of construction characterized by the integrity of assembling and installation, aside disposing advanced raw materials in construction, defined

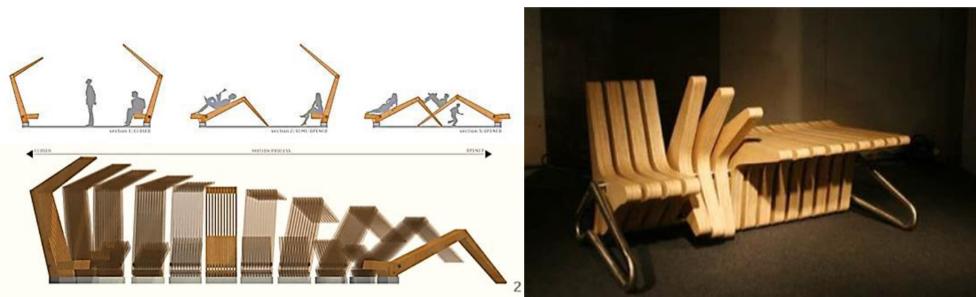


Figure 17, 18: Folding mechanisms in interior's elements to alter their shape and function.

by their light weight, flexibility. Intelligent mechanism systems are inserted as part of the structure such as the folding mechanisms, jaw mounting, and conversion parts to change shape -Shape Shifting-. Some active systems allow the elements of the design to respond to changing circumstances as well as converting infrastructure forms and reshaping the domestic interior spaces. They become interchangeable, designed to respond dynamically to the kinetic movement and different varieties depending on the used materials.

The common and manageable mechanisms applied to the elements of internal spaces are the drawers' sliders. They are intelligent mechanical systems such as self-closing, anti-rebound, and ball-bearing interlocking system, and it was applied to the butterfly extension table to alter its function.

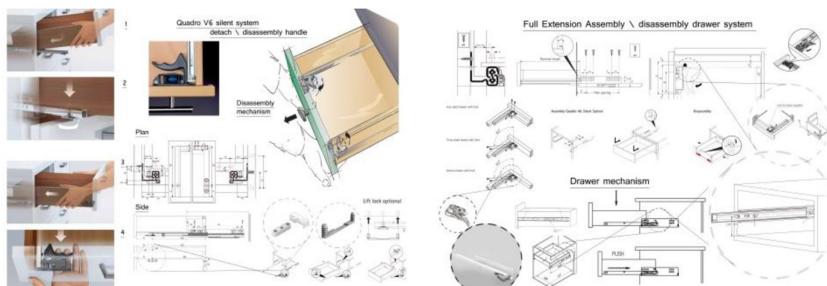


Figure 19: 18, analytical drawings the assembly and mechanism of the drawer slide.



Figure 20: Illustrating the movement and extension of the butterfly table using slides.

6.1.1 Systematic approach of mechanisms

Mechanisms are considered a systematic approach in intricate planning and structural design process. It has a great potential for presenting design solutions and strategies to surmount many complications that the designers encounter [8]. Engineering design is not a concept that can be easily defined, and several terms have emerged to expound the dialectic of the design in architecture and interior spaces which are:

1. **Hyman (1998)** Implies that there isn't a standard definition for the engineering design, but it is the methodology used to solve a certain class of design's quandaries.
2. **Suh (1990)** describes it as the perpetual interaction between what we want to achieve and how to execute it.
3. **Referring to SEED definition:** "Engineering design is a total activity necessary to create and identify solutions to problems not solved before, or in providing new solutions to previous problems that have been resolved in a different way, taking into account the provision of optimal performance."

At every step of the structured dialect, there will be a variety of styles in design and applied technologies endorsing the designer to introduce the best system design solutions with amended quality and efficiency, as well as providing a clear, logical and functional record within the development process to check and analyze later.

6.2 Prospect of kinetic as a motion design concept

Beyond the functional dimension, kinetic structures are those implanted with mechanical mechanisms that transmit motion and force from the source to the output point. With mechanisms, structures coalesce the form and shape of the diverse architectural and interior designs with the mechanical function.

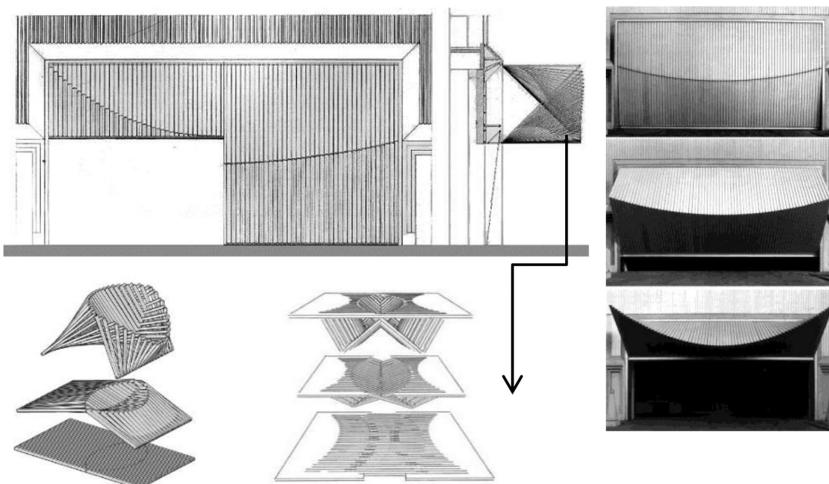


Figure 21: Demonstrating the concept of the raising table and chair and adopting the architectural idea behind the mechanisms and the linkage of the doors of Ernsting Warehouse designed by Santiago Calatrava [9].

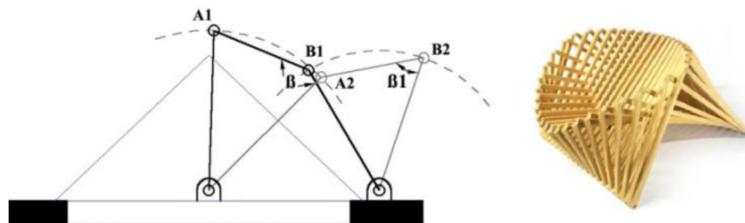


Figure 22: Shows link displacement mechanism.

A mechanism is a mechanical system that transmits motion in a way that all the joints become move contingent to each other, thus interacting to ever-transmuting requisites and conditions with variable geometry or movement through kinetics.

Mechanisms are applied in a great variety of dynamic systems, in buildings, bridges, sculptures and street furniture. Designing kinetic systems are not about inventing, but improving to match an effective function.

Each of the doors elevates and falls through the displacement of an earnest of aligned aluminum slats, articulated in the center of a knee. The canopy's swooping line is due to the gradual and uniform change of the position of articulation along solemn slats: higher at the sides, lower towards the center. The four-bar has some unique arrangements induced by making one or more links illimitable in length succeeding a long output loop. The displacement of the joints and the relative angles between them decipher the four-bar mechanism of the folding shape [9].

6.2.1 Implementation of kinetic systems in interior elements

The kinetic function is an essential feature of dynamic structures depending on a mechanical mechanism for movement, so responsive design appeared as a developmental movement for buildings and the traditional fixed facades altering their functional dimension. It is a response to the spatial adjustment and the interaction with the surrounding.

6.3 Responsive design

The profound responsive design concept is a result of the integration of the function with the computational geometrical technology, translated into constructive spaces and structures



Figure 23: Demonstrating the joint mechanism adapted by the units.

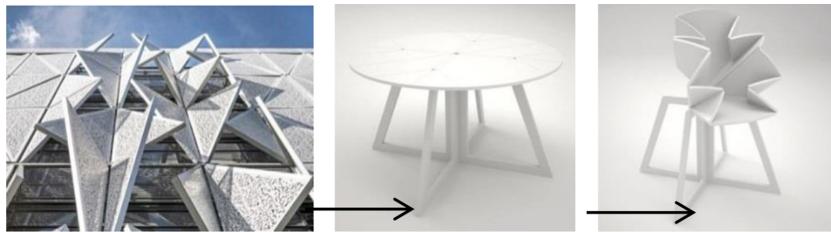


Figure 24: Expanding the folding kinetic system to interior spaces to reshape its form and function.

such as building's facades, covered edifices and interior partitions that respond environmentally, to achieve diversity, transformation, and alteration in a convenient way to the interior space by combining technology and the digital fabrication techniques. The design, therefore, becomes able to imitate the living system.

6.3.1 The importance of the responsive design trend

It is distinguished from other forms of interactive design in the integration of the smart materials in the structural system of elements of the design.

6.3.2 Breathing wall

It is a system bound to the concept that merges the traditional insulation system and the characteristics of the thermal exchange of walls. The goal is heating and ventilation (using the temperature of the building's case to achieve the best air quality in closed and interior spaces. It is a wall designed to allow the transferring of the air into space through a passing insulated layer [10].

With the development of technology and advanced materials, a new concept for breathing wall appeared using the Nanotechnology, the Shape memory textiles. This textile is used inside the space to perform an aesthetic and functional role. Strings of metals alloys consolidate the textile. They are dispersed in parallel in several sections on the surface of the textile to give it the ability to sense heat. When the temperature rises or sensing any changes in the temperature, the metal strings bend to an irregular form, reducing the space between the textile strings, which lead to a remodeling in the form of the textile; when the temperature is standard, the strings retrieve its usual primary shape.

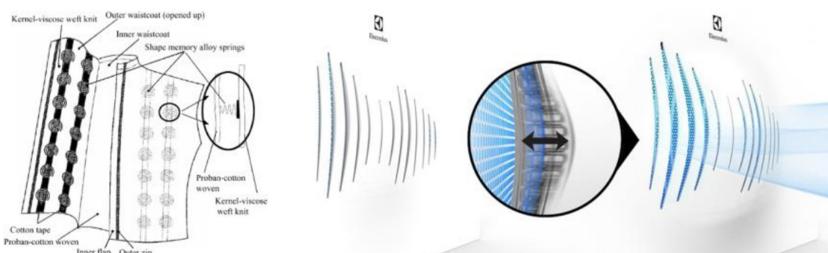


Figure 25: Illustration of the affectivity of the textile with heat and metal alloys.

7 CONCLUSIONS

By approaching architecture and design from a developing trend, such as kinetics, a new opportunity is initiated to engender structures in a creative, efficient, and functional way. Kinetic architecture has demonstrated its advantages. More structures and design's components will perform kinetically and appear in various fabrication processes with the supplemented consequentiality of joints, linkages, and mechanisms. The kinetic behavior has converted the traditional aspect of architecture and design and produced intricate plans and designs with an act of precision. Kinetic systems represent an example of a responsive design conceived as an integral part of a functional significant work of adaptive architecture and suggest an interactive dialectic for understanding the relation of such dynamic components to the design as a whole. It is the new approach of re-thinking of architecture and interior design as an intelligent kinetic system responsive to the patterns and flows of everyday living. Depending on different sciences, it presented a number of solutions to complex predicaments. The advanced technology availed the improvement of the engendered patterns of the materials used in interior spaces, which are flexible and responsive; they changed the traditional patterns and transformed it into an effective conversational language framework in architecture and interior design.

It represents a significant part in determining the style, the construction techniques, and materials. The kinetic design initiated positive steps in the language of rhetoric design integrating formality and thus symbolic as well as functional dimensions to it. The interactive surfaces introduced a dynamic, subversive quality and diversity realized through a range of innovative new materials. The finishing of these surfaces and furniture with a different variety of forms, textures and the ability to add speed, behavior and mobile attributes whose properties are subject to change over time.

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