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The Impact of Dynamic Architectural Facades on The Indoor Environment

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Abstract

Human surroundings are in a state of constant change with an all-time varying dynamism due to the changing forces of nature. It is essential to understand that throughout this science, there are aspects of the building that must remain constant while other parts are subject to change and interaction. Therefore, and in recent years, many interactive solutions have been developed to adapt the building so that it can respond to changes in the external environment; Among the most prominent of these are the interactive dynamic facades, which are considered a new style of buildings characterized by complex simplicity, in both form and construction technology. The research assumes that the application of interactive dynamic architecture to external facades will make buildings responsive and respond to the changing needs of users in light of the challenges of the external environment. To achieve this, the research relies on three study approaches. First, the theoretical study, in which the concepts of dynamic interactive interfaces are identified, followed by the analytical study through presenting illustrative models of dynamic interfaces to the extent of benefiting from the applications of the various technologies used, from which design standards for dynamic architecture are reached, The study also recommends directing scientific and applied research to this study, including it in academic curricula, and activating its application in buildings.

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keywords: Interactive, Responsive, External Environment, Sustainable Design, Kinetic Façades.

1. INTRODUCTION

Dynamic interactive interfaces are the result of the contemporary developments and technology witnessed by the world over the past few decades, which began to accelerate significantly day by day, Adapting design has become a basic necessity to keep pace with the changes occurring in all fields, Especially after the emergence of many contemporary architectural trends and movements, including dynamic (interactive) architecture, whose impact can extend to the environment surrounding the building [1].

Dynamic architecture is distinguished not only by its appearance but also by its ability to control the building in terms of temperature, energy savings, and providing the required protection and safety. The impact of dynamic (interactive) architecture on the environment can be determined through research studies and determining the compatibility of dynamic architecture with multiple environmental systems [2].

1.1. Research problem.

The existence of a contradiction between static architecture and the constantly changing needs of end-users .

1.2. Research goals.

Establishing design standards for dynamic destinations that respond to these needs.
This can be achieved through several secondary objectives:
- Identifying and classifying the concept of dynamic architecture and changing user needs.
- Studying the relationship between dynamic architecture and changing human needs.
- Determining design standards for dynamic architecture to be followed by architects.

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1.3. Research Hypothesis.

The research assumes that by applying dynamic architecture to the exterior facades, the building will become responsive to the changing needs of the users.

1.4. Research Methodology.

The study methodology is divided into three successive stages.
- Theoretical study: Introducing the notion of the research, addressing the concepts and standards of Dynamic Interface Architecture.
- Comparative Analytical study: Analyzing some samples of Dynamic Interface Architecture and deducing results and conclusions.
- deductive study: Proposing an approach in the form of recommendations based on the theoretical and analytical analysis of a case study that meets specific criteria and determining the extent to which it can be applied and proceeding from the theoretical framework to implementation.

1.5. Research Limits.

Time Limits: From the nineteenth century to the present.
Spatial Limits: The most important buildings that belong to the thought and philosophy of dynamic architecture and the extent of their impact on the internal environment.

2. THE GENERAL FRAMEWORK OF THE CONCEPT OF DYNAMIC ARCHITECTURE

There are many different definitions and concepts of dynamic architecture, a new direction that shares some features with other architectural trends and that includes responsive architecture, interactive architecture, moving architecture, and responding architecture; so, it was necessary to clarify some definitions and trends as follows:

2.1. Dynamic Architecture.

The concept represents a new ideology that adds a new dimension to architecture with a dynamic concept of time (the fourth dimension) to make the design process four-dimensional (length - width - height - time) and takes a more attentive character to the external surroundings in order to show the enormous possibilities offered by the technology [3].

2.2. Static Movement.

The forces applied in the design process using computer-aided programs. These forces are implemented through commands that make modifications (movements) to the building design during the drawing phase. Motion is represented as an abstract, formal arrangement [3].

2.3. Dynamic Movement.

Integrating technologies into buildings where the mechanized structures can adapt and change based on climate, needs, or purpose [3].

2.4. Kinetic architecture.

Kinetic architecture is not necessarily dynamic architecture, but it is an architecture whose movement can be partially or fully controlled and still responsive to the surrounding influences [4].

2.5. Responsive Architecture.

Is the type of architecture that has the ability to respond to the needs of end-users constantly [4].

2.6. External environment.

A set of external factors and forces in that have a direct impact on the building [5].

3. TYPES OF DYNAMIC ARCHITECTURE

The start of a new concept in architecture, which is the concept of dynamic buildings that can be found in many forms such as: Static Dynamic, Partially Dynamic and Fully Dynamic.

3.1. Static Dynamic Architecture.

Through this concept, design is achieved by acquiring the mental movement in the shapes through its natural composition, as each shape differs in the effect of its mental movement or even parts of it [6], see Fig. 1.

(a) (b) (c)

Fig. 1. Examples of static dynamic architecture [6]

3.1.1 Visualization and Mass Manipulation.

This process happens by arranging the elements such as curved lines, twisting blocks, basic shapes and its levels to give a sense of movement [7], see Fig. 2.

(a) (b)

Fig. 2. Classification of canyons and their geometric shape according to buildings [7].

3.1.2 Optical Illusion.

Changing the shape of the mass in position, size, orientation, colour, etc... To produce a building with a dynamic force that gives vitality in which the facades consist of two layers of aluminium panels on top of each other along with a back layer of aluminium composite. The angles of placement of the layers vary as shown to give the building a wave-like appearance, which changes with different angles of view [8], see Fig. 3.

(a) (b)

Fig. 3. Refers to examples of buildings that demonstrate optical illusions by curving vertical and horizontal lines to make the facade look like it's dancing [8].

3.2. Partially Dynamic Architecture.

Architecture used to be a site of stability and formal fixation. However, it became mobile and changing in shape whereas it became easy to move some architectural elements that takes part of the components of the building [7], see Fig. 4.

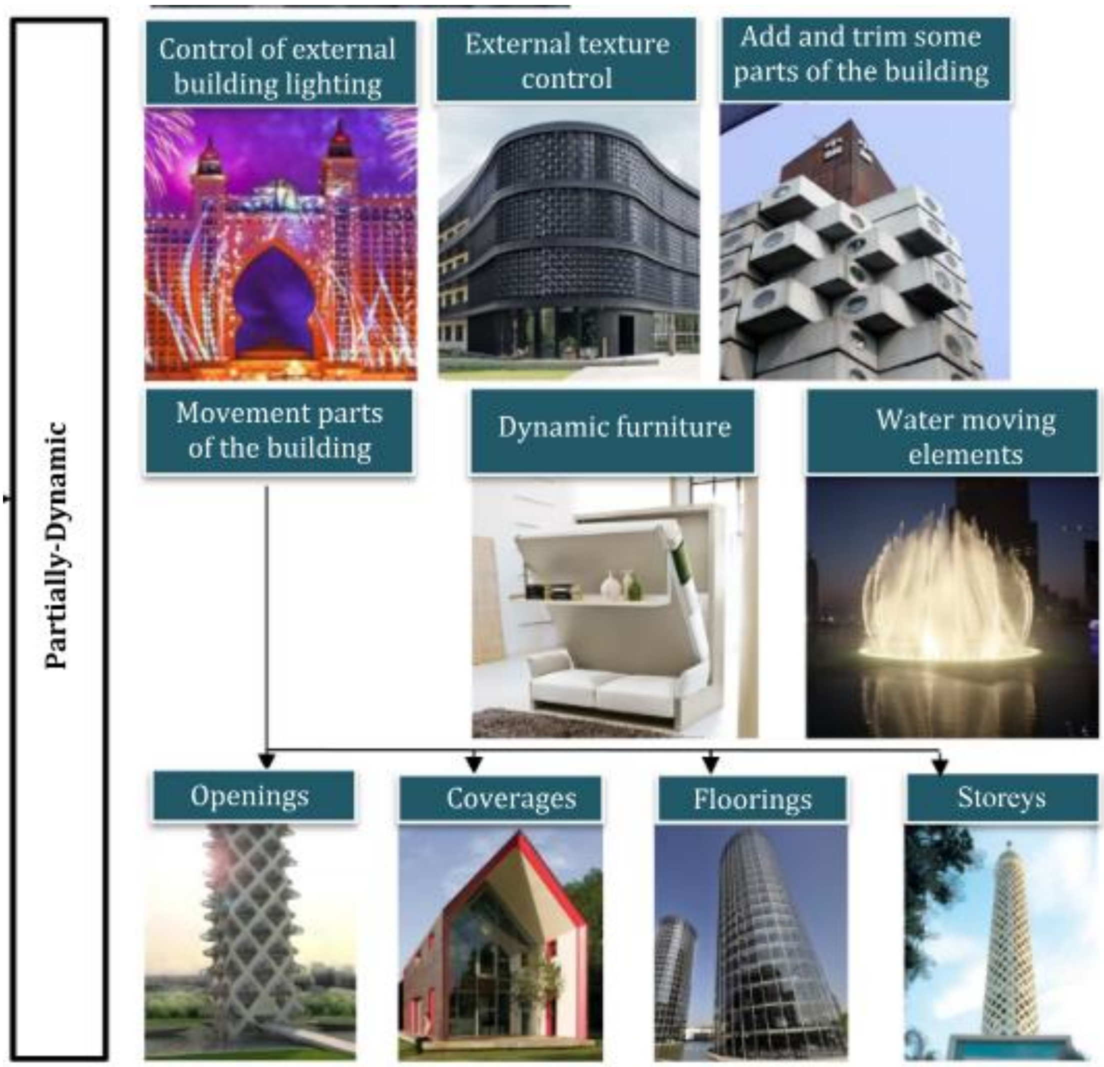

Fig. 4. Shows the types of partially dynamic architecture [7].

3.2.1 The partial dynamics of some elements of the building.

This concept means that the building remains structurally static and some elements of the building only, such as openings and vents, are being partially moved to optimize their functionality [9], as in the “The Devonshire Building” see Fig. 5.

(a) (b)

Fig. 5. The effect of kinetic forces on parts of the building such as openings in the Devonshire Building, University of Newcastle [9].

3.2.2 The dynamics of some parts of the building.

This concept suggests moving some parts of the building, such as floors, while the rest of the parts remain static to maintain the balance of the building, as in the Vollard building in Curitiba, Brazil [10], see Fig. 6.

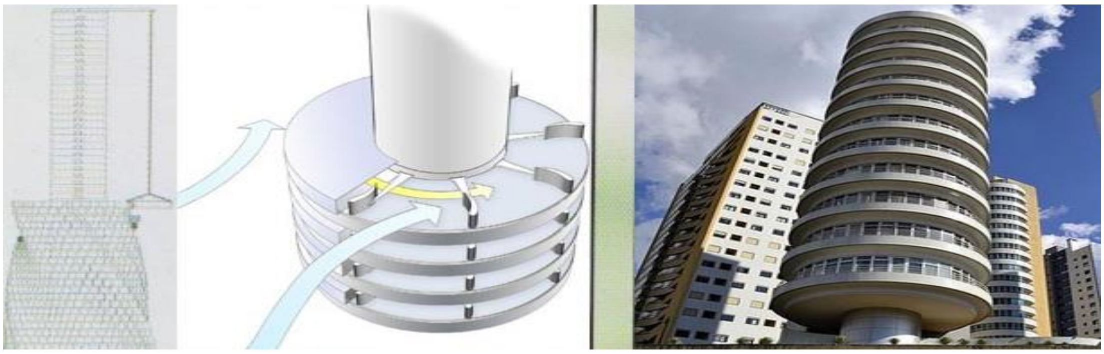

Fig. 6. The effect of kinetic forces on some parts of the building - Vollard building in Curitiba buildings [10].

3.2.3. Fully Dynamic Architecture.

The entire building now or each floor separately can easily move in a particular direction to react to the movement of the sun or wind, as in the Dynamic Tower Building [11], see Fig. 7.

Fig. 7. The effect of dynamic forces on the entire building [11].

4. THE PRIMARY GOALS OF DYNAMIC SYSTEMS

Dynamic systems operate in the building shell as environmental mediators that seek to fully control four key variables and they are as follows: Solar thermal control, Daylight control, Ventilation control, and Energy generation [12], see Fig. 8.

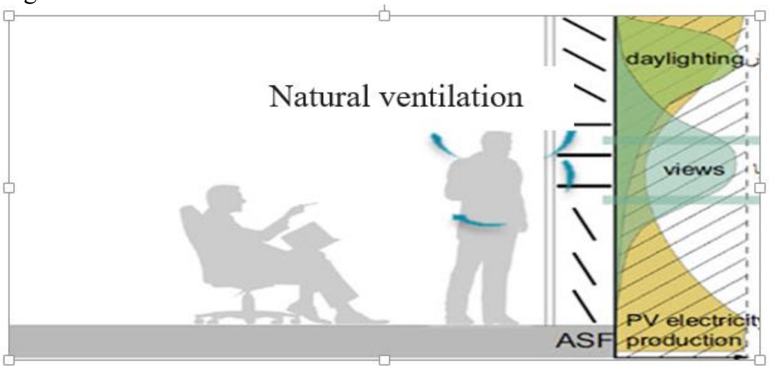

Fig. 8. Refers to the basic functions of Dynamic Systems [12].

4.1. Solar Thermal Control.

With the accessibility of dynamic facades that provide solar thermal control through automated shading units, it aims to either allow or block solar radiation in the building spaces using sensors internally or externally [12], see Fig. 9

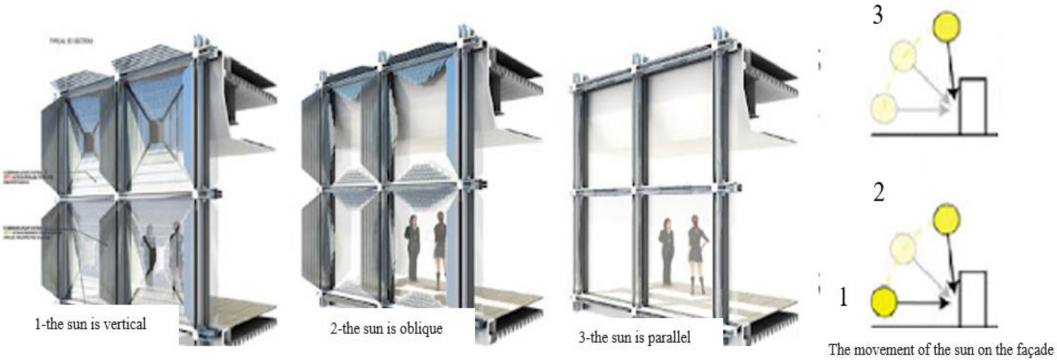

Fig. 9. An example that illustrates the role of dynamical systems through solar thermal control [13].

4.2. Daylight Control.

Daylight control is another vital factor of dynamic facades, which can be achieved using systems similar to those used for solar thermal control, such as blinds, louvers, and overhangs. Louvers are characterized by their ability to control the amount of daylight, which can range from zero to full light leakage depending on the angle of the installed louvers. External awnings or overhangs of windows are also very effective in controlling daylight on southern facades and the selection of any of these systems depends primarily on-site conditions and environmental changes from time to time [2], see Fig. 10.

Fig. 10. The design of the opening and closing mechanisms for the horizontal reflective sun shading in Council House. [14].

4.3. Ventilation Control

Dynamic facades offer great potential for naturally ventilated buildings. Many of these buildings that rely on kinetic ventilation control systems use mobile louvers or DSF (Double Skin Façade). The utilization of these two systems is categorized by a direct and indirect ventilation effect. In the case of direct ventilation, breakers or openers allow direct airflow into the space to directly affect the user whereas many dynamic buildings utilize this strategy such as: One Ocean and Thematic Pavilion EXPO 2012, where the panels move to provide the building's natural ventilation needs by capturing the wind and directing it through the building [15], see Fig. 11.

Fig. 11. The changing shape of the moving plates in the ocean structure is illustrated [15].

4.4. Energy Generation:

Generating the building's energy through its external facades is one of the most important tendencies that many architects have followed, taking full advantage of renewable energy sources. An example on that is the integrated optical systems BIPV (Building-integrated Photovoltaic) [*15*], see Fig. 12.

Fig. 12. Refers to an example demonstrating the role of dynamic systems through wind power generation [15].

5. INTERACTIVE DYNAMIC MOTION PATTERNS

According to their methods of movement and operation, dynamic patterns are divided into three spatial transformation movements: Transitional Movement, Rotation, Scaling, and another motion due to a change in the properties of matter itself, see Fig. 13. Transitional motion is defined as the movement of an object along a uniform plane path, rotation is the movement of an object around an axis, while scaling is the change in the mass of an object by either expansion or contraction. Other complex motion types such as twisting or turning are a combination of these three basic motions. The fourth type of material deformation depends on material properties such as material elasticity [15].

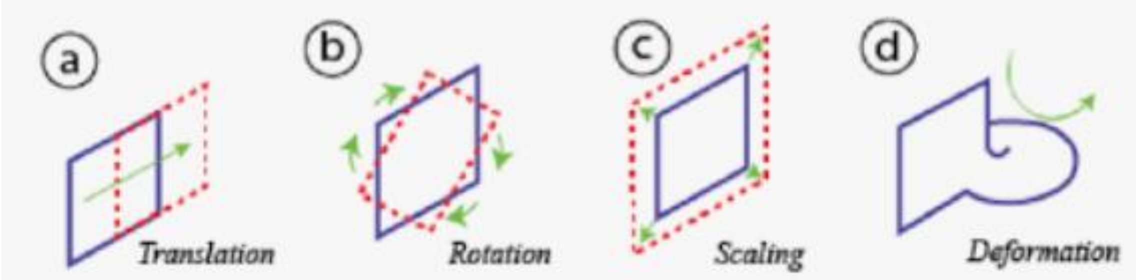

Fig. 13. Refers to the types of Dynamic Patterns based on the methods of operation [16].

5.1. Rotational Motion Patterns:

The rotational movement of an element occurs while it is fixed in its position, as the movement is mostly around one axis and the rotational movement may be in the form of swivel or flap rotation. It is considered built Southern Denmark University Building as an example that clarifies Rotational Motion Patterns in the following table 1.

TABLE 1. SOUTHERN DENMARK UNIVERSITY BUILDING BY RESEARCHER

Southern Denmark University Building (SDU)					
Location	Kolding, Denmark	Construction Year	2014	Building Function	Educational
Architect	Henning Larsen	Motion Pattern	Rotational		

The building envelope's dynamic shading system consists of 1,600 perforated steel triangular segments, which are attached to the facade in a way that allows them to adapt to the changing daylight and desired light flux. Yet, when closed these triangular units are flat along the facade and when half opened or fully open, they emerge from it. The shading system has been equipped with sensors that continuously measure light and temperature levels and also automatically regulate the movement elements by a small engine[3], see Fig. 14.

Fig. 14. Rotational motion system in the building envelope of Southern Denmark University (SDU) [3].

5.2. Folding Motion Patterns:

Represents a mixture of rotational and sliding motions. This dynamic system usually connects the edges or ends of two or more elements in the building envelope, and the movement may resemble a folding sheet or a Scissor fold in the following table 2.

TABLE 2. KIEFER TECHNIC SHOWROOM BUILDING BY RESEARCHER

Kiefer Technic Showroom					
Location	Bad Gleichenberg, Austria	Construction Year	2006	Building Function	Administrative
Motion Pattern			Folding		

The Kiefer Technic Showroom building is an example of a folding system that uses a kinetic envelope. The building is equipped with a software system for electronic opening and closing , see Fig. 15.

Fig. 15. The shape of the facade changes as the units open and close and interact with climatic conditions [8].

5.3. Material Distortion Motion Patterns:

Patterns based on material distortion and state changes represent a new approach to adaptability without the need for mechanically complex systems, as these systems are based on the change in material properties such as elastic deformations and bends.

The Flectofin system is an example of an elastomeric system, derived from the biological analysis of inverse distortions found in plant movement, which has been abstracted into an elastic structure and then into a technical dynamic device. This system consists of a panel, see Fig. 16, or two panels constrained by a driven beam element [7], see Fig. 17.

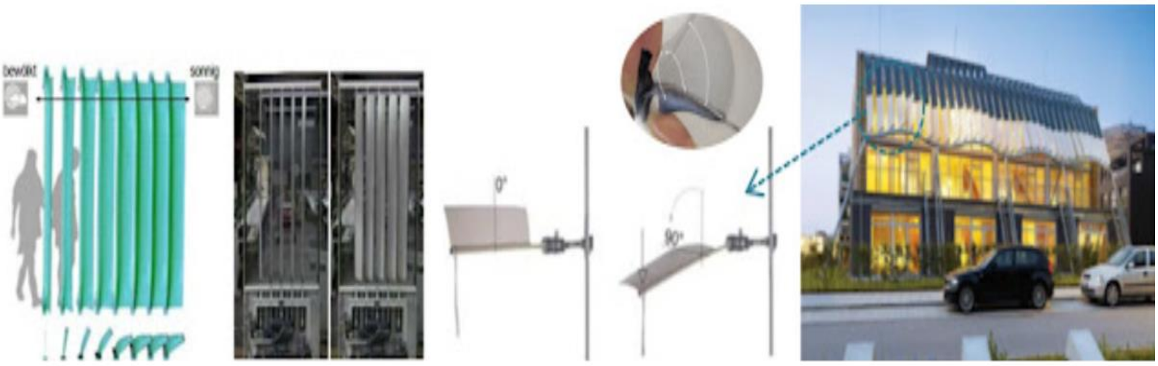

Fig. 16. Flectofin system derived from plant movement (with one plate) [7].

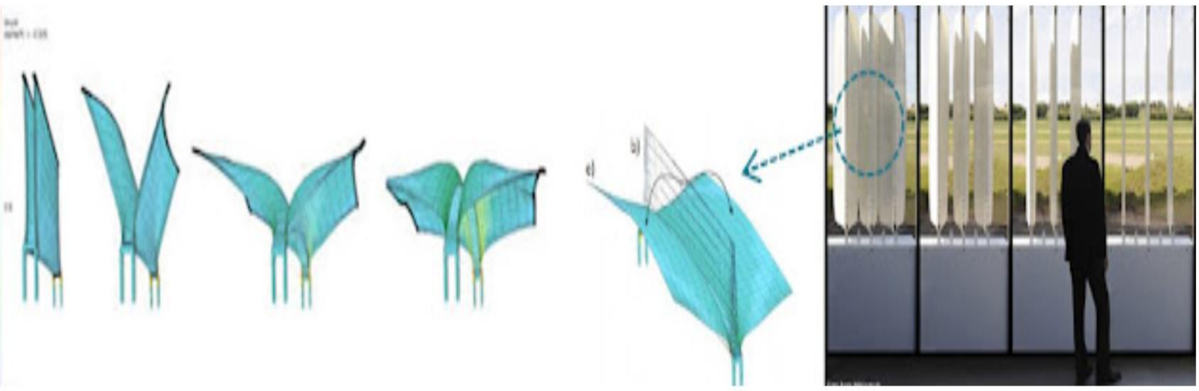

Fig. 17. Flectofin system derived from the movement of the bird's wings that open due to the curvature of the spine (with two plates) [7].

These dynamic systems are mainly based on the study of material properties and behaviors. Bloom is a passive system that opens and closes automatically based on solar heating without the need for artificial energy. The Bloom system consists of laser-cut pieces of thermo-metal, which are assembled into stacked panels that form an environmentally self-supporting structure[16], see Fig. 18

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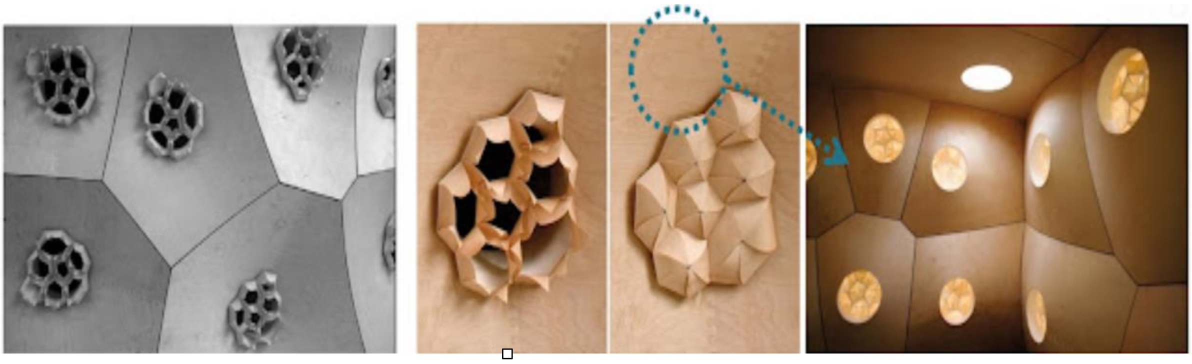


Fig. 18. Bloom system that opens and closes automatically based on solar heating [16]

6. INTERNATIONAL AND REGIONAL EXPERIMENTS

- **Selection Criteria for Case Studies:**

Projects were selected that fulfilled the study's objectives, meeting the following criteria:

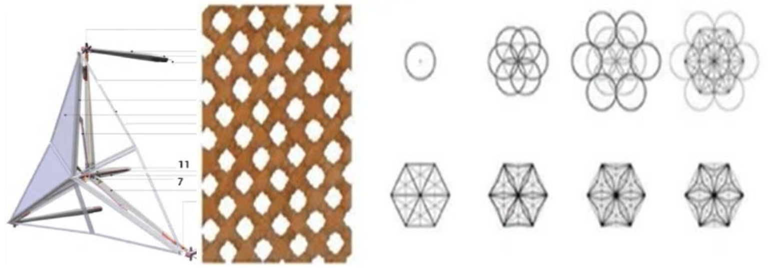
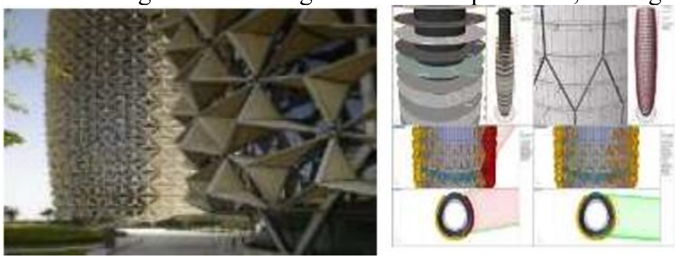
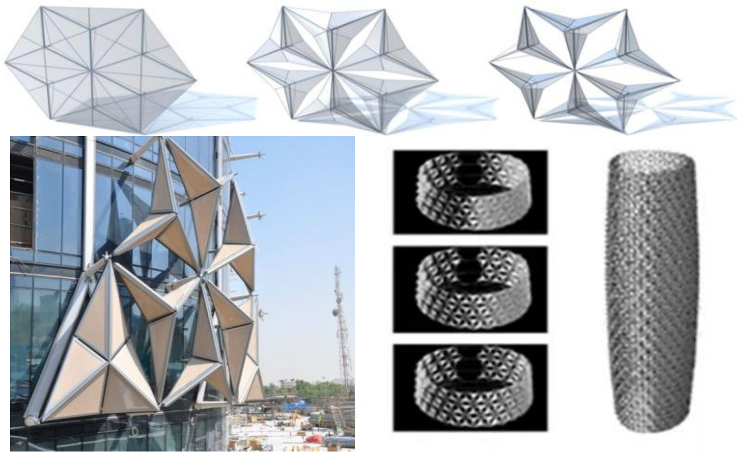
a. Dynamic architecture was the primary focus of these projects.
b. The selected architectural projects were modern and met contemporary design standards.
c. The projects were diverse in terms of their exposure to different climatic elements and their level of adaptation.

- **Study sample**

A number of architectural projects were selected in accordance with the above criteria and to achieve the study objectives, which are as follows: (The sea towers in Abu Dhabi -Mercedes Benz Stadium - sharifi-ha House in Iran)

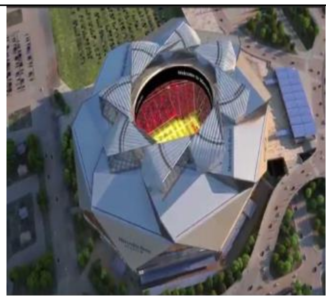
6.1. The Sea Towers in Abu Dhabi

Description:				
Type	Administrative offices building	**Construction Year**	2012	 Fig. 19. AL Bahar Office Towers.
Location	Abu Dhabi City in the UAE	**Architect**	Aedas	
Dynamic Structure	External Façade	**Adaptable Element**	Triple Module	
Movement Pattern	Folding	**Control method**	Electronic control	
Response ETA	Façade changes every 15 minutes			
The design concept	It consists of two towers with a height of 145 meters each with 27 floors in each building; characterized by a structure inspired by beehives and automatic dynamic solar screens that respond to the movement of the sun. It also contains a number of moving umbrellas that may almost reach 1000 units, whereas one unit is 4.2 * 3.6 m each unit is divided into 6 internal triangles, and the weight of the unit is about 62 km. Hence, each unit may move a dynamic piston that follows the reaction resulting from the control system by sensors as a result of a pre-programming calculated according to the climatic conditions externally. The design of the moving units was inspired by the traditional "Mashrabiya" that has been decorating the windows of traditional Arab homes, see Fig. 20.			

		 Fig. 20. Components of a dynamic triple unit figure [17].
The impact of dynamic movement pattern applications on the exterior facade.	**solar thermal control**	These dynamic modules form a number of angles that respond to the movement of the sun in order to minimize the exposure of the exterior facades to solar radiation. The dynamic units move as a result of the presence of a dynamic piston and this piston proceeds to open and close as a result to a previous program that was calculated to minimize direct solar radiation and thus minimize heat gain to be as high as 400 watts per meter, see Fig. 21.  Fig. 21. Dynamic cells during opening and closing and their effect on sunlight [17].
	daylight control	Providing lighting ranging from 250 Lux, which are the appropriate studied values for administrative spaces that are pre-programmed for this space in working periods. Therefore, the designers installed lighting sensors that would read when the measurement is less than the studied value, it automatically connects to industrial lighting, thus providing access to daylight reducing the use of industrial lighting and also reducing energy consumption and industrial air conditioner operating loads, see Fig. 22.  Fig. 22. Ilustrates the opening and closing stages of the units and their effect on the entry of light [17].
	ventilation control	When the solar dynamic panels are exposed to solar radiation, they begin to close, so the movement here aims to prevent the entry of direct solar radiation during working periods, thereby maintaining the ventilation of the space and reducing energy consumption in the use of cooling and air conditioning systems, see Fig. 23.  Fig. 23. Illustrates the effect of the external shell on the internal ventilation of the building [17].
	Humidity	The exterior cladding of the building acts as a wet membrane to control moisture content.
	Achieving Shadows	The units movement provides shading of 70-80%.

	Protection from winds and storms	The outer cover acts as a safety barrier against the wind.
	Power generation	The ease of controlling the envelope has led to a 25% reduction in cooling loads and a 20-50% decrease in solar heat gain.
	The affirmation of belonging and identity	The design of the movable units may have been inspired by the traditional "mashrabiya" that adorned the windows of traditional Arab houses since the 14th century as a form of national identity.

6.2. Mercedes Benz Stadium

Description:				
Type	Football coach	**Construction Year**	2014	
Location	Atlanta - Georgia in the United States of America	**Architect**	Stanley Beaman & Sears	
Dynamic Structure	Roof	**Adaptable Element**	The eight petals of the ceiling	
Movement Pattern	Slipping and spinning	**Control method**	Electronic control	
Response ETA	Opens and closes in a record time of just eight minutes.			Fig. 24. Mercedes Benz Stadium light [18].

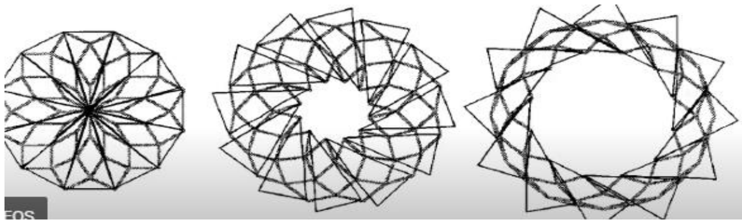
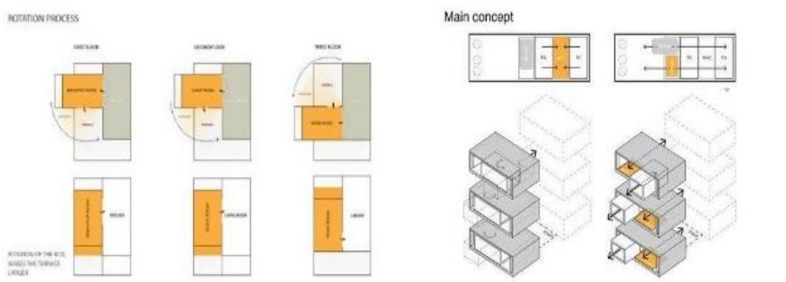
The design concept		The stadium is considered to be the most advanced in the world of football fields, featuring a system that allows for increasing or decreasing the number of seats to reach 71,000 seats. It has air-conditioned seats alongside facilities including restaurants, cafes, shops, and hotels. The stadium is distinguished by having a movable roof, which is one of only five in football stadiums in America, that opens and closes in a record time of just eight minutes. Its shape resembles that of a spaceship, and the stadium has a unique feature of having a panoramic screen in the inner dome of the roof, see Fig. 25.  Fig. 25. Components of the dynamic unit consisting of eight petals light [18].
The impact of dynamic movement pattern applications on the exterior facade.	**solar thermal control**	The eight petals move to close the roof when the temperatures rise, and the façade is made of insulated metal panels and ETFE panels, which help to reduce the internal temperatures of the stadium, see Fig. 26.  Fig. 26. Dynamic cells during opening and closing and their effect on sunlight light [18].
	daylight control	The ceiling opens to allow sunlight to enter and closes for protection from glare, see Fig. 27.

		 Fig. 27. Illustrates the opening and closing stages of the units and their effect on the entry of light [18].
	ventilation control	The materials used in building the roof are ETFE, which is characterized by its resistance to pollutants, dust, and airborne chemicals.
	Humidity	Humidity can be controlled as a result of controlling the temperature.
	Achieving Shadows	The shadows increase when the petals of the ceiling are closed.
	Protection from winds and storms	The ability to close the ceiling petals helps in protection from the winds.
	Power generation	The stadium provides a 29% reduction in energy consumption compared to a typical stadium and has over 4,000 photovoltaic panels capable of generating 1.6 million kilowatt-hours annually.
	The affirmation of belonging and identity	The appearance of the Mercedes logo when closing the roof of cars that financed the Mercedes Benz stadium in order to obtain financial returns for its company (Mercedes-Benz) for cars.

6.3. *sharifi -ha House*

Description:				
Type	Residential	**Construction Year**	2014	 Fig. 28. sharifi-ha House.
Location	Tehran city in Iran	**Architect**	NextOffice–Alireza Taghaboni	
Dynamic Structure	Rotation of blocks	**Adaptable Element**	Steel box	
Movement Pattern	Rotation	**Control method**	Electronic control	
Response ETA	Rotation takes 20 seconds.			

The design concept		The house is distributed over seven floors, and the building was designed with the concept of flexibility in the general site design, where only three rooms can be rotated ninety degrees each, All three rooms can rotate independently of each other, and the original idea is based on the traditional Iranian building that contains a summer and winter living room, The three rooms open in the hot summer to give a beautiful view from the balcony through the large windows, and rotate again in the cold winter to reduce heat loss, see Fig. 29.  Fig. 29. Explain how blocks move in a rotating manner and how the shape of blocks changes [19].
The impact of dynamic movement pattern	**solar thermal control**	The ability to rotate the mass provides thermal comfort throughout the seasons. It changes in response to temperature changes, so the house can close itself when it reaches a moderate temperature.
	daylight control	Achieving an appropriate lighting level through the movement of building

		blocks.
	ventilation control	Ventilation is achieved by designing the handrail details to control air penetration through the foldable handrail design.
	Humidity	The ability of the building to close itself allows for a moderate humidity level.
	Achieving Shadows	Creates shadows by controlling the rotation of boxes, see Fig. 30.  Fig. 30. Shows different house situations in which shade and ventilation are achieved [19].
	Protection from winds and storms	The house works to protect itself from the wind. In the event of strong winds, it closes itself.
	Power generation	A certain amount of energy is saved that would otherwise be consumed in heat treatment, lighting, etc.
	The affirmation of belonging and identity	The opening and closing of the building is a reference to traditional Iranian houses, emphasizing belonging and identity.

7. A COMPARATIVE ANALYSIS STUDY

Comparing projects in terms of dynamic movement patterns for External Interfaces. and its impact on the internal environment in the following Table 3.

TABLE 3. SHOWS THE COMPARISON BETWEEN STUDY MODELS BY RESEARCHER

Elements			Al-Bahr Towers in Abu Dhabi	Mercedes Benz Stadium	sharifi-ha House
pattern applications on the exterior facade	**solar thermal**	The ability to control thermal permeability			
		The possibility of changing the building's orientation			
		Using materials that respond to temperature changes			
	Natural lighting	Taking care to avoid visual overwhelming.			
		Using newly developed smart materials to provide natural lighting.			
		Installation of double-skinned movable external elements to support natural lighting.			
	ventilation	Using the double wall and utilizing the gap for air renewal.			
		Using various smart materials in permeability			
		Using systems that open and close openings automatically.			
	Humidity	Use of fibrous materials			
		Using a moisture control membrane that regulates the moisture content inside the building.			
	Shadows	Using movable external shading devices			
		Using a double wall with integrated dynamic elements in it			
		Using systems that interact when exposed to sunlight.			
		Utilization of wind energy using turbines.			
		Utilization of solar energy.			

	Power generation	Using building movement to generate energy.			
		Relying on multiple sources of renewable energy.			
		Achieving natural ventilation through the movement of building components to reduce the cost of mechanical ventilation.			
		Choosing environmentally friendly materials for their recyclability.			
	Belonging	The ability of the moving building to keep up with the surrounding area.			
		Inspiring moving elements from national, religious, political, or intellectual heritage.			

By analyzing these projects, we note the following:

- Many needs are met when controlling the building's external envelope.
- Dynamic architectural models fail to meet moderate humidity standards, and other needs are addressed.
- Flexibility allows for direct or partial views, including 360-degree rotation.
- Psychological and social comfort is the result of fulfilling many needs and can only be achieved through ventilation, thermal, visual, auditory, and other comfort.
- Although privacy differs from containment, they share common standards.
- Security in dynamic architecture is achieved through the control and management of the movement of the building's components.
- Many dynamic models overlook the achievement of identity; however, dynamic architecture can play a role in developing a sense of belonging by enriching the mental images in the human mind about the place.

8. RESEARCH RESULTS

Thus, the analysis of tactical architecture models may be completed and then some reasons for tactical architecture will be identified, and the extent of its impact on the environment, which will be presented below Table 4.

TABLE 4. SHOWS THE DESIGN STANDARDS FOR DYNAMIC ARCHITECTURE BY RESEARCHER

Design standards for dynamic architecture	
achieving thermal comfort in dynamic design	• The ability to control the building's thermal transmittance by using closable and openable windows. • The building's ability to change and transform throughout the seasons to adapt to changing temperatures. • The use of materials that respond to changes in ambient temperatures or internal temperatures of spaces, such as thermoplastics.
achieving humidity in dynamic design	• Using materials that respond to humidity, meaning that these materials are affected by their water content or internal humidity, which leads to a change in their behavior when they absorb moisture, such as the wood used in the humidity-sensitive pavilion.
Achieving Shading in dynamic design	• Shading elements should be located on the eastern, western, and southern facades of the building, reducing heat gain in the summer and allowing heat gain in the winter to provide heating. • Using external shading methods or absorbent materials . • Using double walls. • Using a smart screen system, which features wires that expand when outside temperatures rise, acting as shading devices for the building. When outside temperatures drop, the wires contract to allow sunlight to enter.
achieving natural ventilation in dynamic design	• Using a double wall and utilizing the space between the static inner envelope and the dynamic outer envelope to recirculate air in the building's interior spaces, with openings that move in the direction of the air. • Using dynamic elements on the north side for ventilation when opened.

Energy generation and conservation in dynamic design	• Harnessing wind energy, which is affected by day and night, is one of the most fertile forms of renewable energy. This can be achieved by using horizontal and vertical turbines in a dynamic building or by using the movement within the building to generate wind energy.

9. RECOMMENDATIONS

- The necessity of developing design awareness in designers by studying the technological methods used to apply dynamic technology and its impact on serving the environment and society.
- The importance of applying interactive technology when designing and redeveloping building facades, as it has formed a new style in the design and technology of construction systems.
- Modifying curricula and establishing new construction methods and systems, as well as modern architectural trends, so that students can understand the principles of modern design.
- There should be an increase in research that focuses on studying modern buildings and various new technologies in construction to keep up with the times.
- The Egyptian code should be referred to in order to improve energy efficiency and the sustainability code for smart cities set by the Ministry of Housing in future studies.
- Design programs should be developed to serve dynamic systems, simplifying the matching of all architectural, structural, electrical, and mechanical drawings and models.

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