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Adaptable Architecture

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***Abstract*: Adaptability to every change a modification and customization is another form of sustainability, especially to climate. Responding to every change in outer and inner environment and adapting to it while making a comfortable environment is adaptable architecture. The paper mentions certain ways to achieve the degree of adaptability either through material or through control systems that adjust according to the user's use and comfort. Dynamics and kinetics are the main subjects through which adaptability and aesthetics are maintained.**

***Keywords*: Adaptability, dynamic forms, kinetic architecture, material technologies, sustainability.**

1. Introduction

Intraday climate change or gradual extreme change in climatic condition is a serious phenomenon to deal with. Past materials and technologies were made to sustain in a one type of climate. Though the climate of india has always been altering, yet it has increased to an exemplary extent that more thought is needed to be given to its solution with sustainability in mind. Certain smart technologies are introduced to help achieve comfortable lifestyle to the users that adapt itself to the changing climatic condition or according to the multiuse. Adapting materials and technologies use mitigation strategies to achieve comfort. The architects now have introduced a new field into sustainability i.e., dynamic and kinetic architecture. Kinetic architecture can be defined by the degree of movement a building does to achieve aesthetics or multiuse. Dynamic architecture is transformation in forms either rotational or translational. These two methods either can be achieved in building envelopes or building plans. Architects need to create a new kind of architecture that moves and is able to re-shape themselves to meet the needs of users. This architecture also needs to be performed so that it can respond to changing circumstances such as weather, time of day and the location of the sun. Smart materials and technologies are introduced to achieve adaptability and sustainability at the same time. The point here is that during the design process, future circumstances are uncertain; Not only do buildings generate unpredictable conditions, but these conditions also develop and change through use and time.

2. Literature review

Certain buildings are designed that adapt itself to climatic change like adapting according to sun path (day and night) and wind movement.

This adapting can be done through kinetic architecture, dynamic architecture and smart material technologies to create a defense mechanism against changeability.

A. Climate change and architecture: Mitigation and adaptation strategies for a sustainable development

- Sergio Altomonte School of the Built Environment, University of Nottingham University Park, NG7 2RD Nottingham, United Kingdom

Buildings are responsible for more than half of worldwide energy consumption, with significant contributions - along with CO2 emissions - to the very causes of climate change. The knowledge gap that exists in relation to emissions from the built environment can be summed up and, at the same time, how buildings and their occupants can be adapted to changes in the global and local climate, including established knowledge, integration of advanced design strategies, application involves innovative technologies and multi-disciplinary research. The paper discusses the interactions between human lifestyle and dynamic environmental form, solve the problem of climate change and connect the building according to phenomenon and the built environment inner and outer surface of building may contribute to mitigate and adapt to these changing phenomenon.

B. The implications of a changing climate for buildings
Pieterde Wilde, David Coley

With the growing global concern about climate change, the construction industry faces the question of how predictable climate changes will affect the performance of buildings worldwide. This results in a rapidly growing field of research that focuses on building adaptation and resistance to changing climates. This review article sets the stage for a special construction and environmental issue on this topic. It discusses the relationship between climate change and buildings and the set of emerging knowledge on the subject, as well as classifies and summarizes contributions on this special topic.

3. Adaptability through dynamics

Transformations can be done through geometrical changes through rotation, translation or a combination of both.

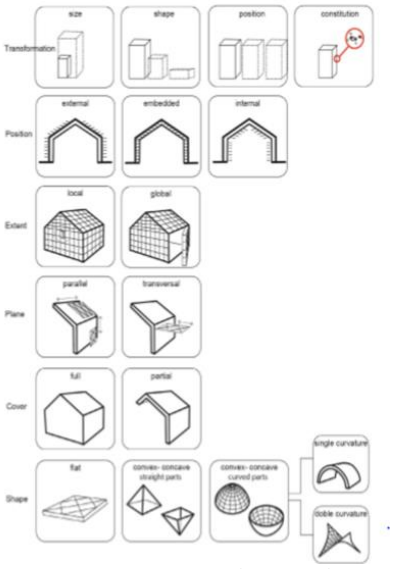


Fig. 1. Adaptive Variability in form transformation.

As several changes happen in a building over time, weather, function, information and human needs, the building must reshape itself multi-dimensionally which is an ideal architecture feature. This can be broken down into certain parameters.

- Time
- Motion
- Speed and acceleration
- Form and patterns
- Mass and weight
- Scale and complexity
- Interactive working on psychology and sociology

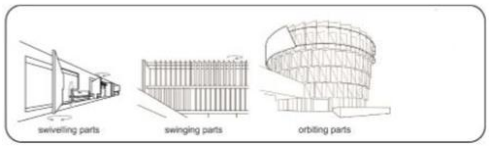


Fig. 2. Rotational transformation

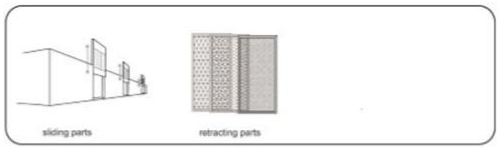


Fig. 3. Translational transformation

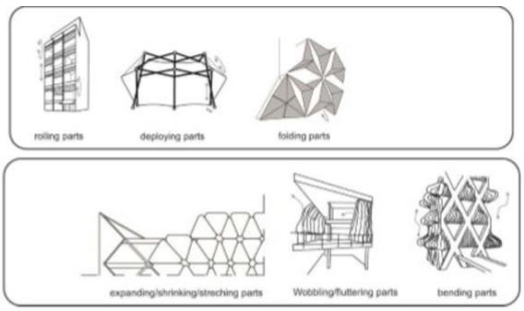


Fig. 4. Rotation+translation transformation

Due to complexity of such structure, the construction cost and maintenance cost is expensive. Yet these structures have evolved from basics and resilient in fulfilling the objective to adapt according to climate.

A. Form transformation

This transformation happens over the skin of the building. The skin changes according to the movement required through modification in shape, position and size. An example can be of a sliding door or swiveling louvers.

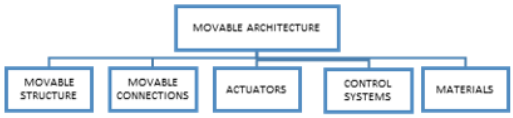
B. Functional transformation

There are climate regulators that work for human comfort by adjusting the environment according to human body comfort. The aspects are thermal energy (temperature, air movement and humidity), electromagnetic energy (visible day lighting, UV light and infrared light) and electrostatic field (noise, vibration energy). Many adaptive structures regulates thermal environment through conduction, convection, radiation and storage. For regulating electromagnetic energy, transparency and permeability of surfaces are altered. For regulating electromagnetism, porosity and shape is altered.

C. Technology

In order to achieve a complex structure, its skin has to be elastic and modifiable to support the movements. The material and mechanical systems are way to achieve it. Easily operable techniques like that of curtains and wood shutters can be used too. Flexibility and operability are the main properties of the skin that can be achieved through porosity, insulation property, transmissibility and surface form modifications.

4. Kinetic architecture components



A. Movable structures

- Convertible structures can modify form and operation
- Compact convertible cantilever in which a beam can be extended to form a cantilever
- Flexible and convertible cantilever are non-mobile yet flexible cantilever system
- Flexible and compact cantilever are on scissor extension principle with telescopic frame like a mobile tower
- Movable bridge structures like swing bridges and bascule bridges
- Movable roof structures are load bearing structures with inflated membrane

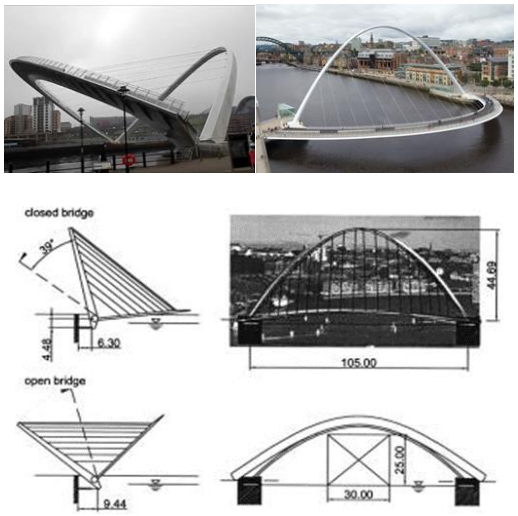


Fig. 5. Gates haed millenium bridge, Newcastle


Fig. 6. University of Phoenix, Arizona

B. Movable connections

Independent components like bearings and hinges are required to establish a movable element. The connecting component facilitates rotation and translation motion to a certain maximum degree and retrained by the constraints.

C. Actuators

The electrical devices that facilitate the movement in the structure as per the guidance of control systems.

D. Control systems

The devices that regulate the system through the mechanics of the structure. It consists of two parts.

- Inputs are the devices that sense or provide the information about the environment like sensors or detectors
- Controllers are the parts that take the input information and then transfer it to actuators to facilitate the movement required.

E. Materials

They decide the extent of movement in the structure. They should be flexible and lightweight like metals (steel, aluminum, zinc, copper), natural fibers (cotton, paper), carbon fibers (diamonds or lonsdaleite) and polymers (elastomers, thermoplastics. Thermosetting plastics).

5. Material and technology

A. SolPix

It's a legal solar powered media wall façade technology that gives power production and sun shading. It's installed for medium to large surface and can be turned into a screen internally. Developed by Simone Giostra, as an intelligent skin that will be software operated. It's like vertical or horizontal panels adjusted according to user's needs.


Fig. 7. SolPix louvers installation

B. Foiltec's Texlon foil system

It's a climatic and transparent building envelop solution that can be morphed into various shapes and forms with thermal and solar controls according to sun's path. With Texlon technology, the building will remain intact in case air supply break down only affecting the thermal environment of the building. It's a aluminum lightweight system consisting of aluminum extrusions and Ethylene-Tetra-Fluoro-Ethylene (ETFE) cushions that doesn't degrade under UV exposure and atmospheric pollution.

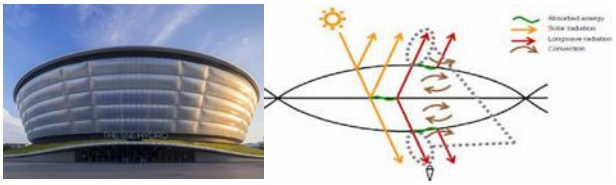


Fig. 8. Foiltec use and light reflection property

C. Articulated cloud

Designed by Ned Kahn, it is a 9-inch squares of perforated aluminum mounted on the façade surface with low friction hinges. During day light the façade appears to look like shadows of sand dunes. The screen changes its looks with wind and appears to float on the façade of the building.

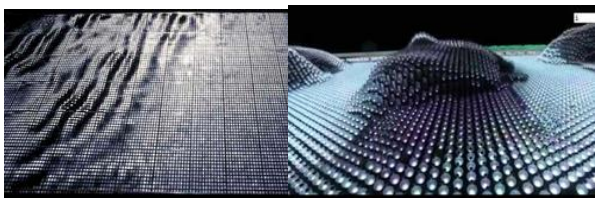


Fig. 9. Use in façade and in-close view

6. Case studies

A. Sharifi-Ha house

Sharifi-ha House is a modern residence located in Tehran, Iran. It is a masterpiece created in 2013 by an Iranian architectural studio called Next Office. It is a luxury home on seven floors which includes an elevator, a swimming pool and a spacious, private gym. But that is not what makes this house unique. The main interesting feature about this 1,400 square

meter house is that its three rooms which look like huge wooden boxes are able to move around. Yes, three whole rooms can rotate to your liking.

That's the great example of the rotational building and perfect usage of the space and transformation, the layout of this residence is extremely complex, especially maximum part of plan is on rotating platforms.

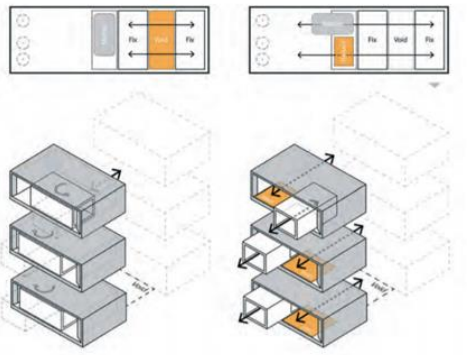


Fig. 10. Concept drawing

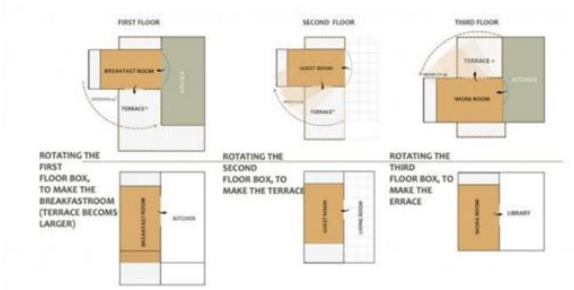


Fig. 11. Schematic plan

Fig. 12. Elevations

The ground floor has parking space and quarters for the housekeeper. The kitchen, lounge room, television room and piano area are all parts of the first and second floors, designed as family spaces. The remaining floors are where bedrooms, bathrooms and additional kitchen and lounge areas are located.

Now comes the interesting part about Sharfiha House. The three revolving rooms remain in a closed state when the weather outside is cold but each room can be rotated up to 90 degrees as the sun shines. All this can be done with the touch of a button. Living in this state, the house gets more ventilation and natural lighting as well as terraced areas.

By the way, the platforms that move the rooms in this house are very similar.

B. User control dynamic façade to comfort zone the interior

Fig. 13. Multipurpose façade

The first type is the "User-Control Dynamic Fascade", an under-construction project (2007) by Kern Technical Showroom, Austria, by Ernst Gazelbracht + Partner. "The way the dynamic façade works is through electronic controls within the building that can control each of the 54 motors individually within the façade. This is a simple technique, which does not involve any type of reactive system and only reacts to the input used from the occupants of the building. The mask itself is acting as a shading tool, but is given to users to control the panel's angle, and amount transmitted in the interior of light.

C. Jean Nouvelle's L'Institut du Monde Arabe (Paris, France)

Fig. 14. Surface view of the building

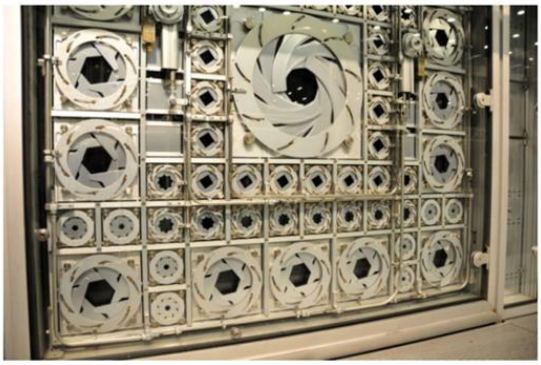


Fig. 15. Façade kinetic mechanism

Jean Nouvelle's L'Institut du Monde Arabe (Paris, France) was created in 1987 and is one of the oldest examples that incorporate the idea of dynamic facades. The south façade is

inspired by the Arab geometry of 'Mashrabia'. Its 27,000 diaphragms, arranged in 113 panels, operate on the principle of a camera lens and control the light level on the south façade via a central computer. The polygon opening of the lens resonates the above Arabic geometries. The structure is now frozen, and it does not really work and has become a question mark in the use of kinetic strategies in architecture.

7. Scope of study

To adapt changes in a future is a common worldwide condition to survive according to new developments and new technologies that everyone has come into prominence within such subtopics as "climatic phenomenon dynamic form, kinetics architecture, adaptation, technology" in architecture. The main objective of the study is to take a step towards the comfortable accommodation of people in all climatic conditions. Structure adapts the climatic change through change in its structure itself. Upcoming future is of the adapting building and technologies in global climate change.

8. Conclusion

To make a building adaptive according to gradual changes of environment and make building futuristic is a main objective of today's designs. Responding to every change in outer and inner environment and adapting to it while making a comfortable environment. Simultaneous respond with changes of exterior environment. As an architect provide comfortable and luxurious life to the users through material or smart technologies. Different material and façade treatment help building to make adaptive. Dynamic form and kinetic architecture make building futuristic.

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