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THE ASPECTS OF EFFICIENT DYNAMIC CONFIGURATIONS IN ARCHITECTURE

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Abstract

The elements and means affecting the formulation and structure of the architectural buildings have been greatly developed by man throughout different ages according to the development of technology. The dimensions and specifications of configuring dynamic buildings can be designed and controlled in order to leave the required effects on the environment and the user to serve a certain purpose or function. However, it seems that the process of formulating any architectural vocabulary acting on the dynamic aspect goes beyond the boundaries of the perceived dimensions and the included unperceived one. The first dimensions may be considered namely the aesthetic aspect in architectural work, while the included unperceived dimensions may display efficiency in work which is greatly influenced by the personality and the formative attitudes of the architect, the site style, and the surrounding environment, as well as the economic efficiency of the building.

However, the absence of the criterion of forming efficient dynamic configurations in architecture is a liability.

Accordingly, this research aims to reach this criterion by identifying the architectural attitudes as a decisive factor in shaping the building as its facades, envelopes, sections or plans. Additionally, it attempts to explain the reciprocal relation between the architectural vocabulary (perceived aspects of configuration) and the unperceived ones which distinguish the valuable architectural works.

The research will attempt to analyze the elements included and the aesthetic and formative considerations while configuring the dynamic building to determine the important role played by such a formation in reaching the psychological and physiological effect on the user to maximize the utilization of such architectural work.

1. Preamble

Dynamic configuration means the presence of motion in the building or a composition and this may appear visually or virtually either vertically or horizontally as it may appear in the elevations and sections of the building or it may appear in the plans and layouts. The paper considered that any configuration extreme of the symmetrical one may be assessed to be a dynamic one.

Many buildings have been designed by pioneers to match the sense of motion, as varied in the perceived and the unperceived dimensions forming this motion. It is considered that the perceived one means the visual sense and the actual motion has known reasoned dimensions of motion. However, the unperceived one is what is going to be studied and assessed in this paper. Mainly, the paper proposes that there are three attitudes forming a decisive in shaping the building and configuring its motion as follows: 1st the site constraints or the surrounded environment of the building, 2nd the development of the societies and the public constrains and 3rd the technological development. Each of them has produced various shapes of dynamic configurations which have to be assessed as means of efficiency (namely the environmental and economic efficiency). So the paper is to be divided into three parts: 1st displaying the attitude

forming a decisive in shaping the building, 2nd is assessing the efficiency of dynamic configuration as a discussion, and 3rd the results.

2. The attitudes forming a decisive in shaping the building

This part of the paper displays the shapes of the dynamic configuration formed as a means of constrains and developments as follows.

The site constrains or the surrounded environment of the building

The environment could be divided into many subtopics that could be studied, however, this paper is concerned with the natural and man-made environments that architects face many challenges to create them. The shape of the site and the site constrains produced the dynamic form as shown in Edgar Kaufmann house 'Falling water' designed by Frank Lloyd Wright, Fig (1) as a stream runs under the house and the stratified stone walls appear to grow from the landscape as they support cantilevered balconies. It seems that Part of Wright's genius was to place the house on top of a waterfall rather than situating it on the adjacent ground with views of the falling waters. Wright had set out to break the box while at work in Oak Park Forty years earlier. In this plan, the service spaces are more enclosed to the rear, while the living spaces in front to break out dramatically onto the landscape. Wright, in his design, didn't cut time as his design matches the time flow and appreciates it in elevations and plans. He used dynamic design in plans by designing small rectangular modules represented by the stairs and duplicated them and adhered to them in an untraditional way to form such a convenient plan for the site. He also accepted the presence of the water flow in the elevations, which is actually dynamic and used the site's raw materials but after reshaping the stones, which means it took a long time for him to produce refined versions of the materials (Fazio et al., 2009).

Another example is Heydar Ali yev Centre Baku, Azerbaijan – 14 Nov 2013 by Zaha Haded in Fig (2). The building design establishes a continuous, fluid relationship between its surrounding plaza and the building's interior. It seems that the plaza has been extended to the interior of the building and the ground surface is accessible to the envelope in an equal sense. The users can define a sequence of event spaces within it. Undulations, folds, and inflections modify the envelope to create an architectural landscape that performs a multitude of functions: welcoming, embracing, directing visitors throughout the center, and blurring the conventional differentiation between architecture and landscape and interior and exterior.

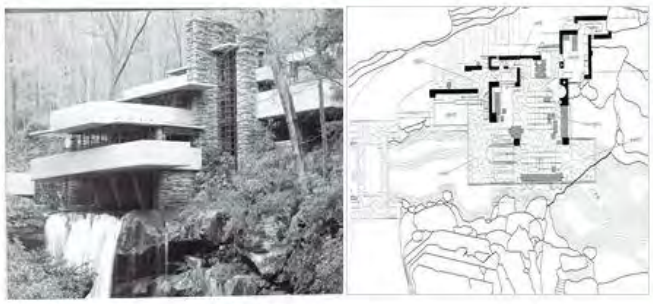


Fig (1) Edgar Kaufmann house 'Falling water' designed by Frank Lloyd Wright

Source: (Fazio et al., 2009)

Fig (2) Heydar Aliyev Centre Baku, Azerbaijan – 14 Nov 2013 by Zaha Haded

Source: googleimages.com

The development of the societies and the public constrains

Any country has its development which is a dynamic discipline with rapid construction, marketing, finance and the regulatory environment. The ever-changing, multidisciplinary nature of the field makes development an exciting and challenging endeavor. Collectively, development decisions have an enormous effect on society given that development creates the built environment, produces shelter and places of work and commerce, contributes a significant portion of global investment, and helps in determining the shape of life in the future. It seems that increasingly, development designs and building materials aim to minimize humankind's footprint on the environment and sustain the economy (Mike et al., 2015). This leads to the presence of three trends as follows:

Mixed-use buildings

Especially in downtown areas, these kinds of buildings are skyrocketing as they represent a way of design or management that avoid urban problems while mapping and can encourage the redevelopment of the downtown area where people can live and work. A single building could contain various functions gathered together as such as stores, theatres, galleries, and government offices distributed in various voids settled to suit their functions (Construction

agency, 2006). This started to exist during the times of the Roman Civilization as the market core shows residential buildings built on top of shops as shown in fig (3). The vertical symmetry of the building was broken by means of the residential building and this led to the dynamic involvement of the building within the urban realm.

Public baths also seem to have mixed uses as the shops seem to penetrate the bath plan but from the outdoors so it breaks the form and appreciates the sense of time as shown in fig (4) (Fazio et al., 2009). Other buildings had the same characteristics as shown in fig (5,6).

Fig (3) Trajan's market, Rome 100-114ce.The markets are built into the hillside as a series of shops that form a semicircle and act as a retaining wall

Source: (Fazio et al., 2009)

Fig (4) forum baths, Pompeii, ca. 80 b.c

Source: (Fazio et al., 2009)

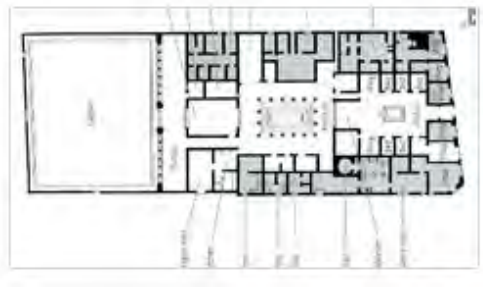


Fig (5) plan of the house of Pansa, Pompeii, 2nd century as it carries several shops and apartments in its lateral body

Source: (Fazio et al., 2009)

Fig (6) plan of the house of the surgeon, Pompeii, 2nd century as it carries several shops in its lateral envelope

Source: (Fazio et al., 2009)

Lately since the 60th century until now, the concept of the mixed-use building spread all over the world (Construction agency, 2006). Mixed-use buildings especially gained popularity when population crises started to take place in the United states where the population was approximately 4 million in 1790 and increased to be approximately 309 million in 2010 and is expected to be 334 million in 2020. Mixed-use buildings, therefore, appeared to be the perfect urban solution as shown in Portland, Oregon, the Brewery Blocks buildings fig (7) which is a mixed- use urban community encompassing seven buildings on five adjoining blocks. Such a project transformed a deteriorated warehouse district into a thriving neighborhood (Mike et al., 2015).

Fig (7) Portland, Oregon, the Brewery Blocks building

Source: (Mike et al., 2015)

The multi-use buildings

This attitude seems to be global and it spread since the reuse of the mega structure buildings all over the world as the buildings nowadays have to be of global envelopes as shown in the Gates Head building in England designed by Norman Foster (https://www.gourmetsociety.co.uk). As shown in fig (8), he designed Sage Gates head on a landmark waterfront site and it was the largest event space in New castle with such a unique shape that matches any function and suites the economic sustainability that represents the main aspect of eco-efficient designs.

Figure 8: The Sage Gates head lies on a landmark waterfront site in New Castle, England

Source: (https://www.gourmetsociety.co.uk)

The mass production portable apartments

It seems that Habitat 67 project designed by the Israeli-Canadian architect Moshe Safdie as the Canadian Pavilion for the World Exposition of 1967 was originally intended as an experimental solution for high-quality housing in dense urban environments. Safdie explored the possibilities of prefabricated modular units to reduce housing costs and allow for a new housing typology that could integrate the qualities of a suburban home into an urban high-rise configuration (Gerick et al., 2014).

The project originated as Safadie's thesis at McGill University in 1961, titled "A Case for City Living" and described as "A Three-Dimensional Modular Building System". Safdie developed his original theories into a complete master plan which contained shopping centers, a school, and 1000 housing units. The scheme was confirmed but was ultimately reduced by the Canadian government to only 158 residential units fig (9).

Habitat 67 was constructed from 354 identical and completely prefabricated modules (referred to as "boxes") stacked in various combinations and connected by steel cables. The apartments vary in shape and size since they are formed by a group of one to four of the 600 square-foot "boxes" in different configurations. Each apartment is reached through a series of pedestrian streets and bridges, along with three vertical cores of elevators for the top floors. Service and parking facilities are separated from the tenant's circulation routes, located on the ground floor.

The on-site prefabrication system should have reduced the cost of production, an integral part of Safdie's vision for creating an affordable housing complex. Unfortunately, due to the reduction of the project's mass scale, costs were much higher than expected. However, though Habitat failed to strike a new wave of prefabrication, it succeeded in creating a new housing typology that is both effective and site adaptable.

By stacking concrete "boxes" invariant geometrical configurations, Safdie was able to break the traditional form of orthogonal high rises, locating each box a step back from its immediate neighbor. This ingenious method provided

each apartment with a roof garden, a constant flow of fresh air and a maximum of natural light: qualities which were unprecedented for a twelve story apartment complex. Habitat 67 thus pioneered the integration of two housing typologies—the suburban garden home and the economical high-rise apartment building. As shown in fig (9).

Fig (9) Various views and plans for the 67 project designed by the Israeli Canadian architect Moshe Safdie

Source: (Gerick et al., 2014).

Tropaco Resort (Habitat St. Thomas) United States Virgin Islands fig (10) is a spectacular rocky peninsula on the north coast of St. Thomas that provided the 12-acre site for this proposed development of 180 condominium units, along with a hotel and other related recreation and convention facilities, to be added in stages. Inspired by the magnificent natural growth of the area and steeply sloped terrain, the design aims for minimal site disturbance. Octagonal modules containing bathrooms, kitchens, and services stack vertically to become support columns based on the ground rock. Larger modules containing living spaces are suspended from the core columns, their windows shaded and ventilated with moveable overhanging shutters. At the base of each column, water is collected from the roof. The client desired a resort that would function equally well as clustered private family dwellings and a guest hotel so that homeowners could rent their units for part of the year. Thus, a building system was designed in which a group of four units with a central glazed courtyard could form either a three-bedroom house or four separate guest rooms around a central public courtyard. The modules were to be prefabricated in 3-inch-thick, precast lightweight concrete at a plant in Puerto Rico, shipped by barge, and then erected on the site by helicopter or mobile crane (Gerick et al., 2014).

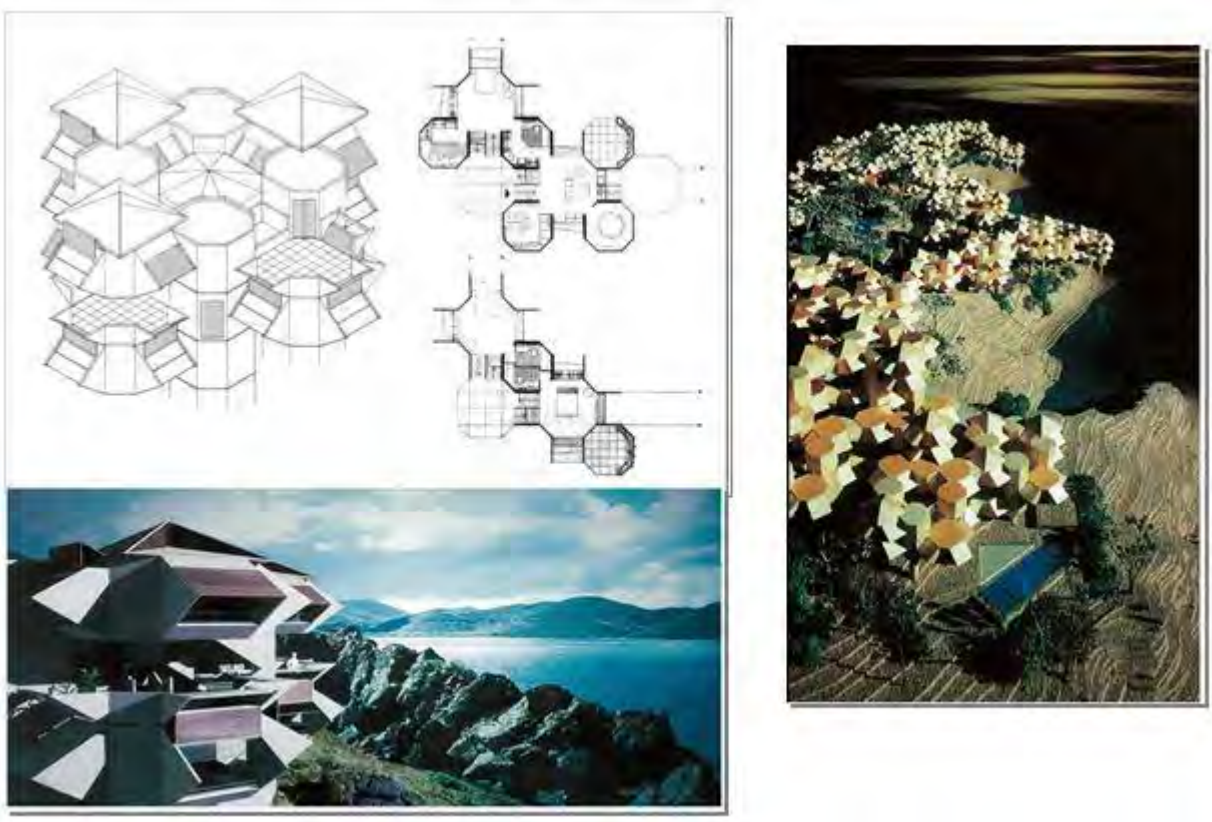


Fig (10) Tropaco Resort (Habitat St. Thomas) United States Virgin Islands

Source: (Gerick et al., 2014).

Recently, the prefabricated assembled panels have been developed as a means of technology as efficient materials have been used as timber to be used as a lower cost material as shown in Jackson clement burrows, caps Schanck, vectoria, Australia. It seems that the living room (left) cantilevers out over the landscape, which it overlooks via full-height sliding doors and a balcony. The study and the master bedroom (right) are accommodated in another timber box supported on slender steel columns. In this building, the master bedroom enjoys views to both the east and the west from large glazed openings. Both windows are protected from unwanted solar gain by external adjustable louvered blinds. (McLeod, 2010).

Fig (11) Jackson clement burrows, caps schanck, vectoria, Australia

Source: (McLeod, 2010)

The technological development

Technology is the main supporter of any development, especially in the building construction sector as it drives the development within four portions as follows:

The development of materials

Materials have been improved in the long run by means of smart and nano-technology as to produce several smart properties aiding in the presence of the motion of the buildings and its contents. As the global response of the smart materials can be detected by two facts as follows:

a. The smart materials used in reinforcement as means of Nano applications as using Nano- carbon tubes instead of using steel to be a way of reinforcement to establish mega structures of huge spaces that can't be applied by steel so complicated forms are established carrying the means of kinetic design as shown in Auditorio de Tenerife "Adán Martín" fig (12) that was designed by architect Santiago Calatrava Valls. It is located on the Avenue of the Constitution in the Canarian capital, Santa Cruz de Tenerife (Canary Islands, Spain), and next to the Atlantic Ocean in the southern part of the Port of Santa Cruz de Tenerife. The building is famous for its great "arc", which is marked as the first in the history of architecture. It is the only large arc supported by only two points, while the tip appears to be suspended, defying gravity. The silhouette of the auditorium as seen from the sea evokes the Sydney Opera House in Australia. The term "The Sydney of the Atlantic"' has come to refer to the city of Santa Cruz de Tenerife. (https://img21.taquilla.com)

Another example is New Jubilee Church (Rome, Italy) fig (13) made of Nano photocatalytic concrete, designed by Richard Meier. The perceptual volume of the church is directly influenced by natural light since the zenith light and the glazed skylights between the successive shells are continually responsive to the changing pattern of light and shadow as the sun moves across its trajectory. According to the season, the weather, and the time of day, light is variously graduated down the inner surface of the shells thereby imparting to the church, the chapel and the baptismal fount a particular character, making it a perfect candidate for postcards printed with some shutter fly coupons to look back on in the future. (http://www.richardmeier.com).

Fig (12) Auditorio de Tenerife "Adán Martín"

Source: (https://img21.taquilla.com)

Fig (13) New Jubilee Church (Rome, Italy)

Source: (http://www.richardmeier.com)

b. The smart materials of kinetic actions as recently smart materials prove the theory of; (every action has a reaction equal in magnitude and opposite in direction). as seen in the smart type of timber composites (Fiber Cement wood) used in fences as it is a flexible material while accepting any force it gives a quick action then returns back to its state without being broken or its durability being affected (www.siamfibrecement.com), as shown in fig (14).

Another example is shown by using Polly carbonate sheets instead of glass to play as a semi-transparent smart material used to reduce the quantity of the absorbed solar heat. As it is to darken and convert into the opaque material while extra heat is received by it.

Fig (14) Smart wood Fence Plank It can be installed over an existing steel fence immediately Interweave, also can be used as stainless fence door to reduce the weight of the door for easier opening and closing. Never derails. It lets air circulate conveniently; install easily and is light-weight to reduce frame costs.

2nd the development of design aspects and techniques

This kind of development aided in the presence of a new version of complex designs and configurations (Dunn, 2012), and it can be displayed as follows:

- Cad: it covers a vast array of programs that produce different results. Some only create two-dimensional drawings, whilst others are capable of highly sophisticated three-dimensional renders and animations. It is required to control a CAM machine to create, manipulate, and refine the design ideas, as shown in fig (15).
- NURBS has a great role in the production of a wide range of geometric forms, ranging from simple volumetric solids to extensively detailed, complex surfaces. It requires Rapid prototyping machines to create (Curvilinear surfaces), as shown in fig (16).
- Meshes: The most frequently used meshes are polygonal or Polyhedral as Polygonal meshes are widely used in computer graphics and a significant array of algorithms exists to facilitate ray tracing and rigid body-dynamics. It requires (CNC) computer numerical control milling and routing to create an instructed model, as shown in fig (17).

Fig (15) example of CAD design products

Source: (Dunn, 2012).

Fig (16) example of NURBS design products

Source: (Dunn, 2012).

- Curvilinear formation: The reason for this surge is curved surfaces and forms were very difficult to design and fabricate. This led to experimentation with tectonics that continues today as architects explore the nature of facades as fluid skins and building programs as curvilinear organizations and spatial flows. It requires (FDM) Fused Deposition Modeling which forms layers by extruding small beads of thermoplastic material that hardens immediately after extrusion. It is used to create the Visual-kinetic installation, interactive wall, double curvature surfaces, and curvilinear geometry as shown in fig (18).

Fig(17) example of Meshes design products

Source: (Dunn, 2012)

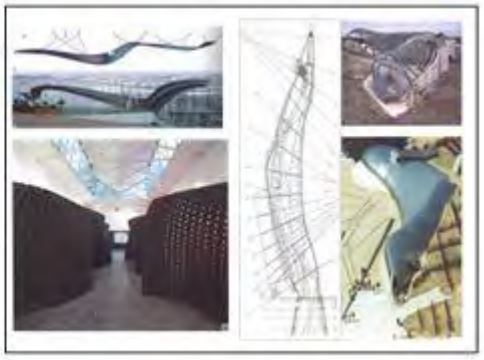
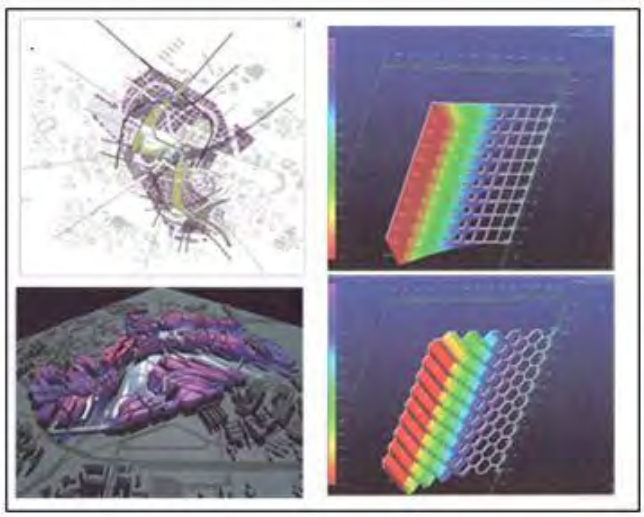


Fig (18) example of Curvilinear formation

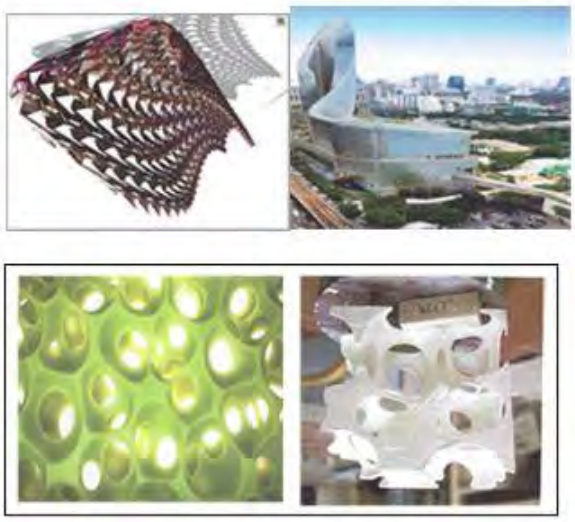
Source: (Dunn, 2012)

- Parametric Generative Design: Enables the designer to define the relationships between elements or groups of elements, and to assign values or expressions to organize and control those definitions. It is usually applied within a three-dimensional cad program. It replaces the designer's direct interaction with the design elements- adding, subtracting, copying, etc. by which elements connect and build up the design, conceptual mass/form as developed for implementation, as shown in fig (19).
- Morphogenesis: it is the evolutionary development of form in an organism or part thereof, morphogenesis is a developed study of how performativity formal behaviors undefined by typological expressions may be produced by integrated design methodologies to create Innovative and speculative design features, as shown in fig (20).



Fig(19) example of Parametric Generative Design

Source: (Dunn, 2012)



Fig(20) example of Morphogenesis designs

Source: (Dunn, 2012)

The development of the implementation techniques

There are five recent techniques that can be used to convert the complex designs into real implemented ones as follows:

- (CNC) Routing and Milling: it is a computer numerical control milling and routing that can cut three-dimensional objects or surfaces using CAD file from a solid material such as timber, aluminum, foam, and carbon fibers. The Machine can cut through three or more axis enabling 3D forms to be created and it helped in contouring. It enables the designer to remove material through a series of carvings or contours. It is also capable of quickly producing a greater number of either non-standard or repetitive elements, fig (21).
- Laser cutter: Laser cutter can slice through the material or engrave patterns on to its surface using a CAD file. The technique can be used to sculpt a range of materials, including plastics, wood board, and paper, and it helped in folding the surfaces as it seems to be an integral feature of many contemporary architectural

designs, aided by the ability of computational to fold and unfold designs. Folding is very economical in material terms, as shown in fig (22).

- Rapid prototyping: Rapid prototyping machines "print" in three dimensions from a CAD file. The project is built up "layer by layer" each new layer is bonded or melted into the previous one. It includes:
    a. (DMLS) direct metal laser sintering
    b. (FDM) fused deposition modeling
    c. (SLS) selective laser sintering
    d. 3D printing & 3D scanning

This technique helped in Forming: as it is a key way of making a curvilinear element. It has been used to make such architectural elements as façade panels. It is an effective and economical method of making a significant number of components so it saves effort, time, and cost, as shown in fig (23).

Fig (21) example for contouring by . (CNC) Routing and Milling

Source: (Dunn, 2012)

Fig (22) example for folding surfaces

Source: (Dunn, 2012)

Fig (23) examples of forming by using Rapid prototyping

Source: (Dunn, 2012)

- Water-jet cutter: it uses a fine jet of water mixed with abrasive matter to cut a range of hard materials including iron, steel, concrete, stone, laminated wood and composite resins. It helped in Sectioning: as it is a method of profiling components in relation to a surface geometry. By taking a series of sectional cuts through a digital model, it offers a quick and effective way of gathering the necessary data to inform a CAD/CAM process as shown in fig (24).
- Plasma –arc cutter: it is used to cut steel and other metals. As the inert gas passes through a nozzle at high speed and in conjunction with an electrical arc, which turns some of the gas into plasma that is at such a high temperature it can cut through the metal. This helped in Tiling, a geometric strategy is used extensively in the built environment it is also referred to as "tessellating" involve the development of figures or shapes that when assembled together form a coherent plane without gaps or overlaps.

Fig (24) example for sectioning by using Water-jet cutter

Source: (Dunn, 2012)

Fig (25)examples for Tilling by means of Plasma –arc cutter

Source: (Dunn, 2012)

The development of the environmental control systems

Various systems are used by means of technology to match the passive solar energy design and acts as a means of a motion in the building. As one of them is using the double and triple glassing systems to reduce the received heat from

the openings so it seems that by using Nanotechnology in the aero-gel glass panels (Leydecker, 2008) in the windows and skylights to improve the heat isolation of the space, the aerogel itself acts as a kinetic fat as it converts its color while receiving more heat. Fig (26). Another example shown in the usage of the movable shutters is the passive solar habitat designed by Aaron Beyers Fig (27) which appears to be an aspect of the sustainable living and it allows for the ability to co-exist with the natural environment. It also uses the dynamic motion. This project expands upon techniques of passive solar housing by utilizing local resources and investigating methods inspired by its natural habitat as the timber used in the claddings and all the structural elements and the design overall are perceived as a composition of recyclable materials minimizing cost, labor and site impact. Moreover, it represents dazzle utilizing the movable shatter that is found externally on the envelope to protect it from a hot climate and ventilates the building (https:// www.hustpass.com).

Fig (26) the aero-gel glass panels

Source: (Leydecker, 2008)

Fig (27) Passive solar habitat designed by Aaron Beyers

Source: (https:// www.hustpass.com)

3. Discussion

This part of the research assesses the efficiency of dynamic configuration as such efficiency must be related to economic and environmental efficiency to satisfy the call for eco-efficiency which seems to be the call of the era. Sustainable development depends on the building economic life and appreciates the flexibility as a concept to reach efficiency which proves that developers are agents of change. Design is, therefore, far more than aesthetic configurations so the phrase that was coined by the architect Louis Sullivan " form follows function" in the late1800s is truer today than ever as sustainable design is softer on the environment and more energy efficient and cost-effective to manage over time but all within smart and developed technology.

Today, architects, landscape architects, and other designers take a holistic approach considering a host of factors when designing a new project or redevelopment. Their goals include making the most of the site and location, minimizing energy consumption, using the most environmentally friendly materials, conserving water, enhancing indoor air quality, and optimizing long-term operational practices.

At the same time in the marketplace, the ability to turn data into useful information often makes the difference between profit and loss. So the data may be the constrains of the buildings site or its society's development that must be converted by suitable technology to suit the issues of the era and the kind of efficiency needed as shown in almost all the previous examples displayed in the paper which consumed to reflect the kinds of the dynamic configurations.

4. The results

Kinetic architecture is used to be a plan for more than one kind of motion of the building given that it is based on economic sustainability, the environmental control issue and the techniques of technology. So the main criterion of designing the kinetic building stands on two kinds of motion as follows:

The actual motion which appears in the plans, sections, elevations and 3D modeling of the form:

- The dynamic configuration in plans is an informal movement of the main module and its ratios in the site or the curvilinear designs forming innovative configurations orienting the user to his trip in the building in an exciting way allowing him to appreciate the time and it may be making a role of convenience with the climatic environment.

- The dynamic configuration of sections and elevations and 3D modeling as the presence of the variation of ratios in the volume of the levels prove the presence of the mixed use. Or the presence of motion of the same volume of the typical voids in various levels of the building proving the mass production which refers to the economic efficiency. Or finally the presence of the digital configurations which are mainly produced by the presence of hi-technology to introduce a multi-use building.
- The motion of any content of the building as shown in its environmental control systems and materials

2nd the virtual but efficient motion which is the unperceived aspects of motion related to economic efficiency while time passes as the actual presence of the building in its right phase of the economy. But while Consuming that technology is the main means of kinetic configuration, the following table summarizes the criterion that may be used to design and implement efficient kinetic configuration.

Table 1.shows criterion used to design and implement efficient kinetic configuration

<table>
<tr><td>The kind of efficiency</td><td colspan="3">The aspects of kinetic configuration</td></tr>
<tr><td rowspan="2">Economic efficiency</td><td rowspan="2">Flexibility</td><td colspan="2">Kind of building use</td></tr>
<tr><td>Mixed use</td><td>Multiuse</td></tr>
<tr><td rowspan="2">Environmental efficiency</td><td rowspan="2">The convenience of the design with the surrounding environment</td><td colspan="2">The environmental control aspects</td></tr>
<tr><td>Smart materials</td><td>Smart systems</td></tr>
<tr><td>The efficiency of technology</td><td>Design techniques</td><td colspan="2">Implementation techniques</td></tr>
</table>

Source: researcher

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