

## Parametric Design Between Design and Application in contemporary Architecture

Dr. Eman mohamed alhawty

Lecturer at October high institute for engineering & Technology

Department of Architecture Engineering

[Emymh10@yahoo.com](mailto:Emymh10@yahoo.com)

### Abstract:

The paper discusses the correlation between the impact of technological development and environmental compatibility on architecture.

The research seeks to clarify the most important aspects of this effect as part of the analysis of the theoretical study data.

This development is reflected in design processes, building materials, construction systems, implementation methods, and more.

This led to the development of architectural thought in the use of digital design methodologies, modern construction materials and innovative implementation methods. All these elements led to the formulation of a contemporary architecture that differs in its concept from the concept recognized in previous trends before the era of information technology.

In the recent period, theorists have overlapped and varied opinions on how to achieve a balance between the capabilities of technology and the determinants of the environment in order to produce an objective architecture in terms of performance that does not concern itself with form without content.

This research presents a methodology for measuring the extent of contemporary architecture communicates with the place. The methodology relied on the various theses that call for establishing a balance between authenticity and contemporary, and which are used to evaluate the architectural practices that are continuous with the place.

Parametric architecture is a style of contemporary architecture. Which has spread to the world in recent years.

The process of creating the Parametric Model is an important stage in the digital design process in general and the parametric design process in particular.

Prepares the parameters it provides, who does the design work, who does the custom design work. By adding or changing one of the elements in the parametric model structure.

The architecture that was exhibited accompanies the trap that appears after the current display to display images, cool techniques, dynamic modeling techniques, and parametric modeling techniques.

### Research problem:

Activating the role of parametric design and using it to obtain design solutions characterized by simulating nature, borrowing its details and measurements, and re-representing it.

### Research Importance:

The importance of the research is the ability to renew in architectural design and solve the problems of legalizing complex forms of design and characterizing some forms of nature in a

simplified form according to a numerical computational system based on the concept of information.

#### Force search:

Using parametric design, we can find flexible solutions to design problems within the spaces of shapes inspired by nature, and this leads to a new model for design thinking and support for inspiration from nature.

#### Research Methodology:

The research follows an inductive approach

#### Research goal:

The research aims to reach the integration between parametric design and sustainable architecture through its applications and impact on architecture, taking into account its disadvantages and taking advantage of its advantages.

#### key words:

Parametric Architecture - Contemporary Architecture - Digital Design.

#### ملخص :

يناقش البحث العلاقة التبادلية بين تأثير التطور التكنولوجي والتوافق البيئي علي العمارة فيعمل البحث علي استيضاح لأهم مظاهر هذا التأثير وذلك ضمن تحليل معطيات الدراسة النظرية فيظهر ذلك التطور في عمليات التصميم ومواد البناء ونظم انشاء حديثة وطرق تنفيذ مبتكرة ادت كل هذه العناصر الي صياغة عمارة معاصرة تختلف في مفهومها عن المفهوم المتعارف عليه في الاتجاهات السابقة قبل عصر تكنولوجيا المعلومات .

وفي الفترة الاخيرة تداخلت وتنوعت اراء المنظرين في كيفية تحقيق التوازن بين امكانيات التكنولوجيا ومعدات البيئة من اجل انتاج عمارة موضوعية من الناحية الادائية لاتهتم بالشكل دون المضمون .

فيقدم هذا البحث منهجية لقياس مدي تواصل العمارة المعاصرة مع المكان , اعتمدت المنهجية علي الاطروحات المختلفة التي تدعو لانشاء التوازن بين الاصاله والمعاصرة والتي يتم استخدامها لتقييم الممارسات المعمارية المتواصلة مع المكان .

العمارة البارامترية parametric تعتبر نمط من العمارة المعاصرة والذي انتشر علي مستوي العالم في السنوات الاخيرة . تعد عملية انشاء النموذج البارامترى parametric model مرحلة مهمة في عملية التصميم المعماري بشكل عام و في عملية التصميم البارامترى بشكل خاص

يعد التصميم البارامترى في العمارة المعاصرة منهجا تصميميا مهما في عملية التصميم الرقمي يقوم علي اساس مفهوم البارامترات والذي يؤدي الي التنوع عن طريق تغيير قيم البارامترات دون التأثير علي كيان التصميم فيسمح النموذج البارامترى للمصمم المعماري باعادة التشكيل الجيومترى دون اعادة الرسم ويساعد كذلك في اكتشاف البدائل التصميمية من خلال اضافة او تغيير احد العناصر في هيكل النموذج البارامترى.

تتضح تقنيات التصميم المعماري التي رافقت الثورة الرقمية والتي اثرت في العمارة المعاصرة والمتمثلة بكل من تقنيات الواقع الافتراضي و تقنيات النمذجة الديناميكية وتقنيات النمذجة البارامترية

#### مشكلة البحث :

تفعيل دور التصميم البارامترى واستخدامه للحصول علي حلول تصميمية تتميز بمحاكاة الطبيعة واستعارة تفاصيلها وقياساتها وإعادة تمثيلها.

**اهمية البحث :**

تتمثل اهمية البحث في القدرة علي التجديد في التصميم المعماري وحل مشكلات تقنين اشكال التصميم المعقدة وتوصيف بعض الاشكال من الطبيعة في صورة مبسطة وفق نظام حسابي رقمي يقوم على مفهوم المعلومات.

**فرض البحث :**

باستخدام التصميم البارامتري نستطيع أن نجد حلولاً مرنة للمشكلات التصميمية داخل الفراغات من الاشكال المستلهمة من الطبيعة وذلك يؤدي الي نموذجاً جديداً للفكر التصميمي ودعم الاستلهام من الطبيعة .

**منهجية البحث :**

يتبع البحث منهج استقرائي

**هدف البحث :**

يهدف البحث الي الوصول للتكامل بين التصميم البارامتري والعمارة المستدامة خلال تطبيقاته و تأثيره في العمارة مع مراعاة سلبياته والاستفادة من ايجابياته.

**الكلمات المفتاحية :**

العمارة البارامتريية - العمارة المعاصرة - التصميم الرقمي

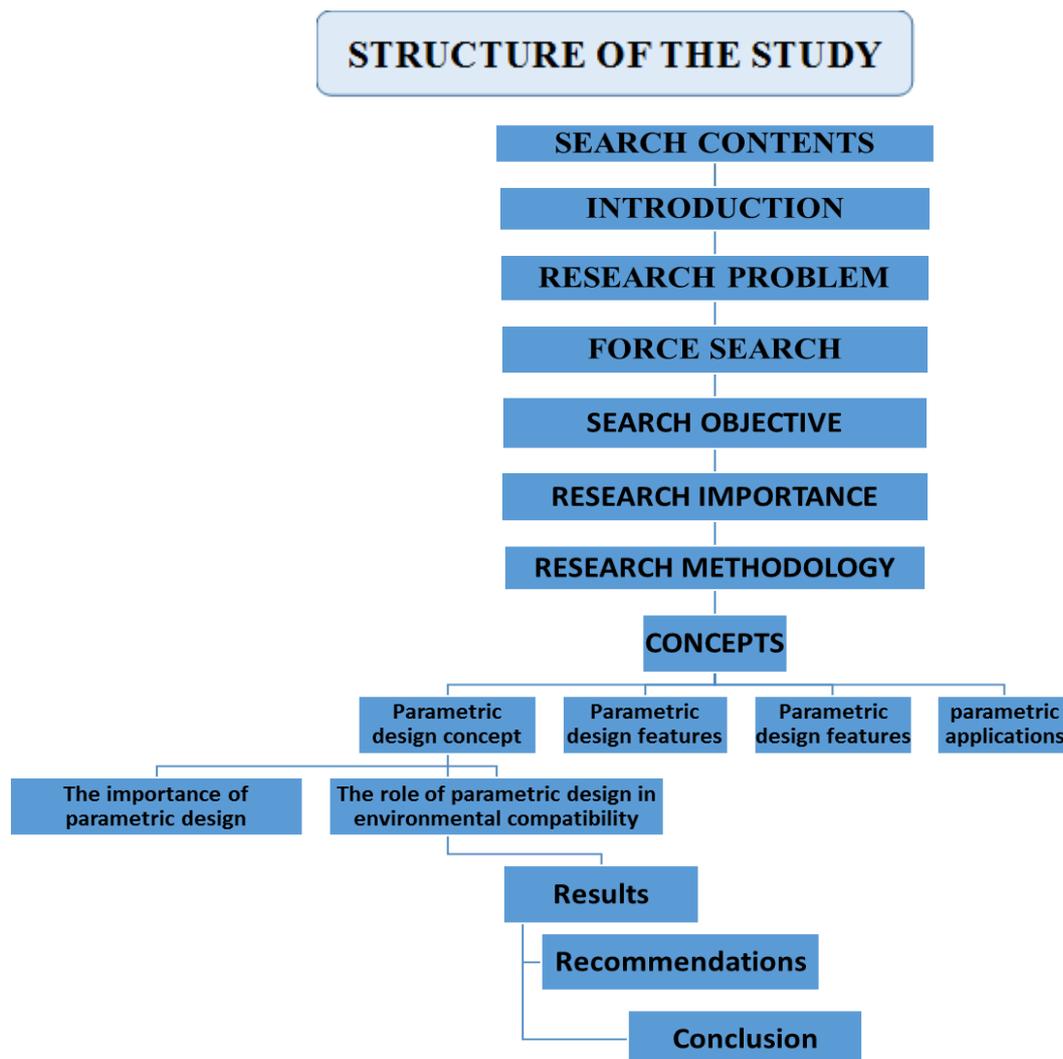


Figure (1) structure of research

## Introduction

The rapid development of digital technology has contributed to the emergence of new approaches to contemporary architectural design

The entry of digital media into the world of architectural design enabled architects to find architectural blocks that were difficult to express and represent by traditional means.

This tool also gave him the opportunity to test the formation he reached, whether in terms of plastic design, construction or environmental terms, in addition to the possibility of modification and discovery of design weaknesses during the effectiveness of the design and not after implementation

Parametric design in contemporary architecture is an important design approach in the digital design process based on the concept of parameters, which leads to diversity by changing the values of parameters without affecting the design entity.

By adding or changing one of the elements in the parametric model structure.

The architectural design techniques that accompanied the digital revolution and that affected contemporary architecture, represented by virtual reality techniques, dynamic modeling techniques and parametric modeling techniques, are clear

Employing digital technologies in contemporary architectural trends

Dynamic modeling techniques are employed in architectural formation within many directions in environmental architecture, including:

### Hypersurface architecture

It represents a new architectural trend that works on the interaction between the electronic space and the environment by presenting advanced ideas for architectural surfaces and materials.

The architecture of interactive surfaces depends on the ability of the computer to easily deal with irregular B-SPLINE curves and the surfaces from

which it stems are physically interactive, and the dimension is in the third axis in the surface

The reactant is not stable, as the structure of the upper surface used in this design is interactive in its ability to control and dynamic in its texture, for example:

Al Bahar Towers in Abu Dhabi, which consists of a group of semi-transparent components that open and close in response to the path of the sun. Each of the towers contains more than 1,000 individual shading devices that are controlled by the building management system to create a smart facade



Figure (2) Al Bahar Towers in Abu Dhabi

The entire installation is protected by a variety of sensors that open the units in the event of cloudy or windy conditions. The external structure is two meters away from the glass structure of the building and is designed in an independent frame.

Each triangle is coated with fiberglass and programmed according to the movement of the sun. At night, the canopies remain folded, allowing the main glass facade of the building to be visible. And when the sun rises in the early morning in the eastern area of the building, the umbrellas in the eastern area open and whenever the sun moves to cover the other areas of the building, the umbrellas follow and open according to the movement of the sun.



Figure (3) Using Mashrabiya in Al Bahar Towers in Abu Dhabi

The solar energy that enters the area that enters the area, the surrounding area, the solar energy consumed by the air conditioning. In addition, the time of the awnings saves the energy consumed by the lighting during the day.

The benefits of this design are: Reducing glare, improving daylighting inside the building, reducing the use of artificial lighting, and a 50% reduction in solar energy gain.

### Parametric design

is a design methodology based on parametric modeling and scripting techniques.

This methodology might be productively employed on any architectural design, independent of the architectural style the designer might be adhering to.

All styles can benefit from the advantage of maintaining design malleability during the design's progressive resolution.

Parametric design is thus equally applicable to all architectural styles and in this sense stylistically neutral.

Pragmatism is the contemporary style that is most vigorously advancing its design agenda on the basis of parametric design techniques.

Conceptual and Operational Definition of Pragmatism:

Pragmatism implies that all architectural elements and compositions are parametrically malleable. This implies a fundamental ontological shift within the basic, constituent elements of architecture. Instead of the classical and modern reliance on ideal (hermetic, rigid) geometrical figures - straight lines, rectangles, as well as cubes, cylinders, pyramids, and (semi-)spheres - the new primitives of pragmatism are animate (dynamic, adaptive, interactive) geometrical entities - splines, nurbs, subdivs, particle-spring systems, agent based systems ect.

- as fundamental 'geometrical' building blocks for dynamical compositions that react to "attractors" and that can be made to resonate with each other via scripts

### **Parametric design concept**

It is a new approach in architecture and arts that emerged with the digital system and its various application programs, in order to renew the architectural design according to a numerical algorithm based on the concept of information.

It depends on the inclusion of many determinants of the building to be designed such as the length, width, height, weight and material of each of its elements in order to form a reliable information base in making decisions during all stages of the implementation of the design model, and that is why some define it as (design modeling), or standard design. or modular or modular design

### **Architectural Origins of Parametric Design**

Parametric design is based on engineering foundations known as algorithms.

It is a number of sequential and logical mathematical steps that lead to the solution of a problem. In simpler terms, it is a key to any issue and the necessary input and output steps. These algorithms had an effective position in computer science and mathematics, and also helped to perform various arithmetic operations on computers

Parametric design also relies on borrowing and re-representing nature's details and measurements.

Therefore, it is closely related to morphology, which studies the shapes and functions of plants, living organisms, and non-living things represented by rocks that bear a wonderful geometric design, which is an important source of creativity in architectural design.

God has endowed us with a beautiful nature, and everything in it has been a source of inspiration and creativity for man in formation and design, and he has tried to benefit from it in aesthetic and utilitarian designs for the environment since ancient times.

Parametric design is a modern tool that enables the designer to understand the complex formations in nature and to deal with them in a simplified manner within a codified framework within different theories, and through various computer tools and programs, through which the parametric design is achieved, such as the DMAxorut (Inodeskut 3) program. Like (Scripting, Grasshopper).

Pragmaticism as a design movement emerged in the 1960s.

Among the first architects to implement it were the Spanish Antonio Gaudi (1858-1926 AD), and the German architect Frei Otto (1925-2015 AD).

These two tried to find a way, such as the methods found in nature, to obtain curved shapes, which are used in building the optimal shape for domes and curved surfaces

The Iraqi architect, Zaha Hadid (1950-2016 AD), is one of the founders of this trend in architecture and the arts.

She rose to prominence in the early eighties, and her mark was prominent in the engineering world.

Hadid is also considered one of the pioneers of deconstructive architecture, and has always been known as an architecture that transcends predetermined barriers to architecture.

It was distinguished by its ability to renew and appear in more free and daring forms; Consolidating the abstract and dynamic concept of mass in its three dimensions.

She moved away from straight architectural lines and right angles, and her designs were characterized by curves and oblique lines.

Thus, she was able to introduce oblique and sloping forms into the lexicon of architectural design, and for this reason she was known by the title (Queen of Curves), as well as the title (Abstract Woman), and her colleague German architect Patrick Schumacher followed her approach, who believed that parametric architecture was able to integrate all architectural elements and transformed them into elements or unitary logarithms.

Easy to transform and shape, which helps to strengthen the relationships between the components and forms of the project and the relationship of the building with its surroundings. His works were characterized by an excessive fluidity of forms that came as a result of the development of drawing and digital design, and as a result of the mixing of architectural concepts with mechanical art and other arts, especially abstract art.

### **Parametric design features and benefits**

The parametric design has several advantages, perhaps the most important of which is its reliance mainly on flowing and curved lines that resemble fabric and are characterized by smoothness and movement, and this gives the design a unique shape that attracts attention. This type of design is also characterized by its reliance on living geometric entities instead of using classic geometric shapes such as a cube, cylinder, pyramid, and others. One of the most important principles and basic priorities of parametric (dynamism, relevance and adaptation).. It is characterized by ease of implementation and manufacture due to its use of repetitive units, and it is also subject to modification and change at any time; When making any modification in any part of the design, it appears automatically in the rest of the parts, thus it shortens the great time and effort required to implement and experiment with these modifications manually, and the materials and raw materials used in the parametric design are varied; Where iron, wood, glass, paper, fabric, rubber, plastics and others can be used, which helps to produce various assortments characterized by their great imitation of nature.

One of the advantages of the parametric design is that all its elements are adaptive and interconnected in a smooth and soft way. different.

Parametric design has been able to find flexible solutions to design problems within the spaces.

It helps give the illusion of movement and space as a result of repetition and extension. It can be used as a kind of cladding for old and damaged areas without re-finishing them again, in addition to giving them new functional and color values through the integration and overlap of material and color in an integrated and harmonious manner. It is suitable for use in interior and exterior designs and even in the design of various pieces of furniture, etc., and blends architecture with sculpture.

Opening the door to unconventional shapes

The importance of this new style of design lies in the fact that it opens up vast and diverse horizons in architecture and the arts, and enhances the creativity of designers in the production of thousands of designs. It also allows the designer to explore unconventional forms that he could not imagine on his own, which in the past seemed unrealistic and unattainable.

Finally, the use of computers in design helped designers and architects to present us with wonderful and innovative designs full of dynamism and movement, through which they were able to express their ideas and embody them in attractive designs characterized by flexibility and flow, and achieve aesthetic values.

The importance of parametric design

The parametric design and its effective role in digital architecture trends are clear. Parametric design represents the medium that strongly influences the emergence of new ways of digital design in contemporary architectural designs.

As the parametric design does not only affect the formal characteristics of the designs, but it also produces a new model of design thought.

**The research can crystallize the importance of architectural design in the following:**

- 1-Generate and discover multiple design alternatives
- 2- Flexibility and adaptability
- 3- The possibility of using parametric design at different stages of the design process during design and construction.
- 4- The ability of the parametric design to represent and model complex geometric shapes
- 5- Parametric design has an important role in performance design
- 6- Application of modeling

**The role of parametric design in architectural environmental compatibility**

The development of parametric modeling techniques has allowed a compatibility between the design functions and the geometry by means of expert systems and the rules of the form. Performance evaluation and modification of the geometric model, which leads to performance-based design processes.

The design process of the Swiss Re building in London by Architect Forster is a preliminary case study of a performance-based approach, including a parametric design controlled by an interactive process towards improving performance. The building facade and shell are modified according to structural performance and wind load. The performance is structural or environmental represented by the performance of solar energy.

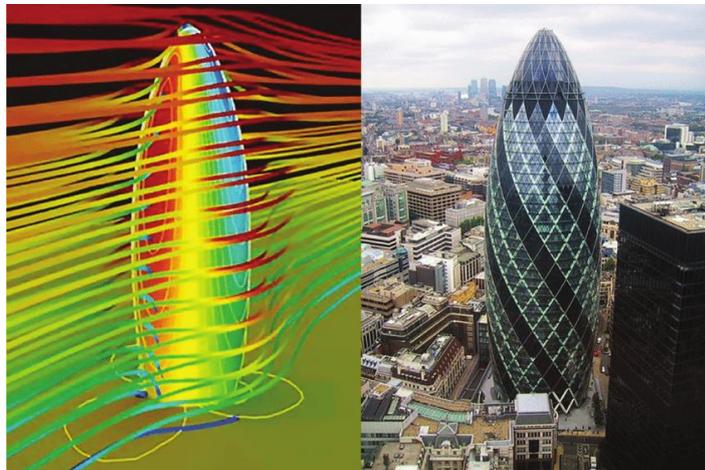


Figure (4) the design of the Swiss Re building in London

In the design of the City Hall of London, the parametric design was employed to treat the curved shape of this design, which is not only an aesthetic expression, but it helps reduce the area of its outer surface by 25% than any other formation, and then reduces the heat energy gained from outside and the energy lost through the cover, which It achieves optimum thermal performance.



Figure (5) the design of the City Hall of London

Structural principles are an integral part of the design process. Through the creation of parametric models, new possibilities arise that allow a more integrated design process. The architect and structural engineer can communicate through parametric models that allow structural analysis and help the structural engineer to make correct decisions by obtaining geometric explanations and changing design requirements. continuously .

**The application of parametric modeling in a variety of design standards ranging from building design to interior design:**

The parametric orientation allows designers to achieve complete fluidity in all stages of design from initial sketches to construction. Below are a variety of parametric design applications.

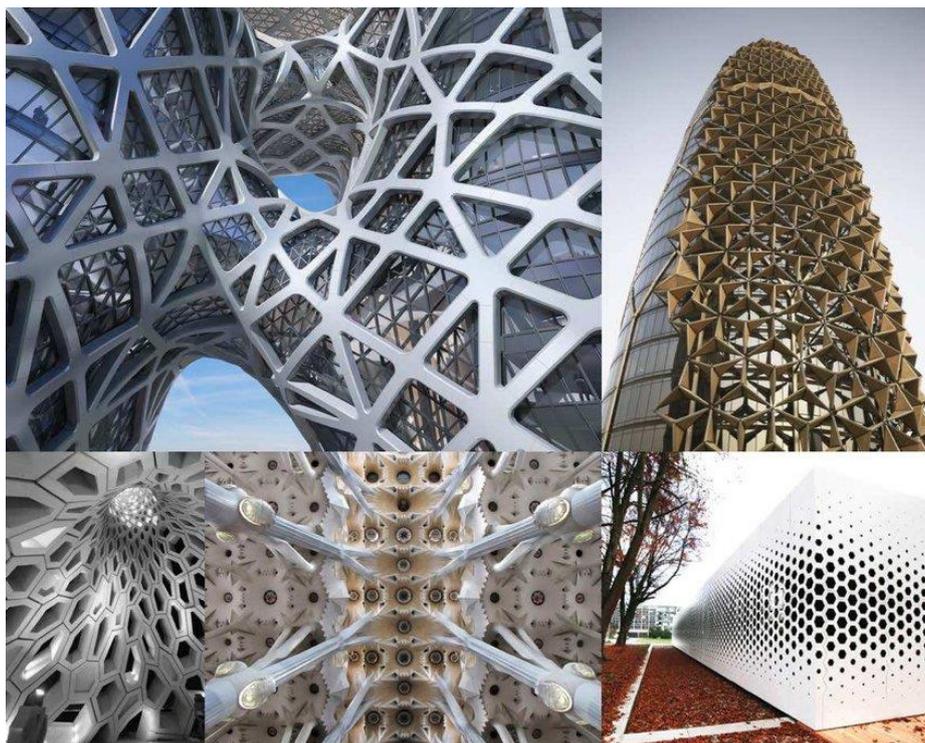


Figure (6) Parametric design in in the external coverings of buildings



Figure (7) Parametric design in interiors



Figure (8) Parametric furniture pieces



Figure (9) Parametric furniture pieces

### The Parametric Modelling Process

Parametric models are built from a set of mathematical equations. For parametric models to have any legitimacy, they must be based on real project information. It is the modernity of the information examination techniques and the breadth of the hidden undertaking information which decides the viability of a modelling solution.

### There are two popular parametric representation models:

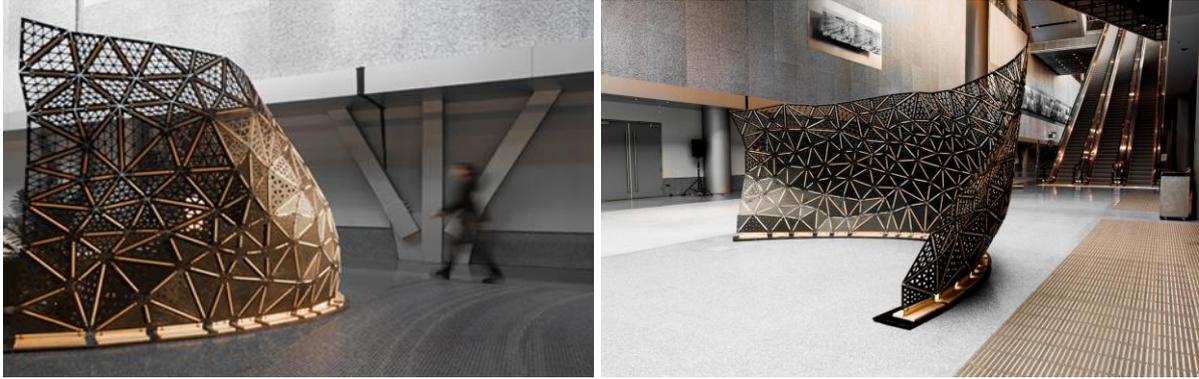
#### Constructive Solid Geometry (CSG)

CSG defines a model in terms of combining basic (primitive) and generated (using extrusion and sweeping operation) solid shapes. It uses Boolean operations to construct a model. CSG is a combination of 3D solid primitives (for example a cylinder, cone, prism, rectangle or sphere) that are then manipulated using simple Boolean operations.

#### Boundary Representation (BR)

In BR, a solid model is formed by defining the surfaces that form its spatial boundaries (points, edges, etc.) The object is then made by joining these spatial points. Many Finite Element Method (FEM) programs use this method, as it allows the interior meshing of the volume to be more easily controlled.

**parametric applications**



**Figure (10) TED 2018 INSTALLATION BY STUDIO ROBAZZO**

Design an elegant space partition installation at TED2018: The Age of Amazement. They were faced with the problem of creating intimate moments within the gargantuan hall of the Vancouver Convention Centre, and needed something that would break up the space without being clunky or awkward.

create a visual impact in the ‘quiet areas’ of the TED2018 Closing Celebration.

gave Robazzo a brief to create dividing walls that would be visually appealing and also bring height to the space. Robazzo used their innovative digital design process to create custom walls that not only added height and created separate seating pods, but their unique and complex design also added visual appeal and an extra level of dimension to the space. VIP guests enjoyed the quiet seating areas in what now felt like a thoroughly designed experience and the walls themselves became a talking point.”



**Figure (11) GUANGZHOU OPERA HOUSE BY ZAHA HADID ARCHITECTS**



**Figure (12) GUANGZHOU OPERA HOUSE**

The design evolved from the concepts of a natural landscape and the fascinating interplay between architecture and nature; engaging with the principles of erosion, geology and topography. The Guangzhou Opera House design has been particularly influenced by river valleys – and the way in which they are transformed by erosion.

Fold lines in this landscape define territories and zones within the Opera House, cutting dramatic interior and exterior canyons for circulation, lobbies and cafes, and allowing natural light to penetrate deep into the building. Smooth transitions between disparate elements and different levels continue this landscape analogy. Custom moulded glass-fibre reinforced gypsum (GFRC) units have been used for the interior of the auditorium to continue the architectural language of fluidity and seamlessness.



Figure (13) SERPENTINE PAVILION BY BJARKE INGELS GROUP

The Serpentine Pavilion, designed by Bjarke Ingels Group (BIG), was an ‘unzipped wall’ that was transformed from straight line to three-dimensional space, creating a dramatic structure that by day housed a café and free family activities and by night became a space for the Serpentine’s acclaimed Park Nights programme of performative works by artists, writers and musicians. Kunlé Adeyemi’s Summer House was an inverse replica of Queen Caroline’s Temple – a tribute to its robust form, space and material, recomposed into a new sculptural object. Barkow Leibinger were inspired by another, now extinct, 18th century pavilion also designed by William Kent, which rotated and offered 360-degree views of the Park.

Yona Friedman’s Summer House took the form of a modular structure that could be assembled and disassembled in different formations, and built upon the architect’s pioneering project La Ville Spatiale (Spatial City) begun in the late 1950s.

The materials include wooden floors and extruded Fiberline profiles, providing every surface with a warm glow and linear texture – from the mesh of woven glass fibres to the undulating lines of the grain of wood.

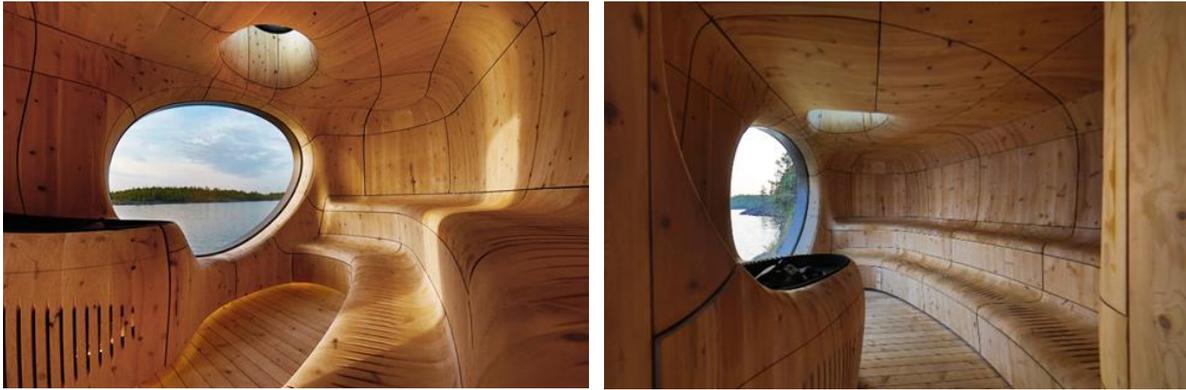


Figure (14) GROTTA SAUNA BY PARTISANS

Perched at the northwest edge of an island in Georgian Bay, Ontario, the Grotto Sauna is a feat of old-world craftsmanship and new-world sustainability made possible by cutting-edge software and fabrication technology.

A simple but dignified exterior built from charred cedar prepared using the traditional Japanese Shou Sugi Ban method conveys a weathered appearance—it's as if the building has been hidden in plain sight for centuries. The warm, curved interior emulates Lake Huron's waves and mirrors the Precambrian shield—a soft, undulating rock surface that has been worn over billions of years.

**These are the benefits** offered by 3D parametric modelling over traditional 2D drawings:

Capability to produce flexible designs

3D solid models offer a vast range of ways to view the model

Better product visualization, as you can begin with simple objects with minimal details

Better integration with downstream applications and reduced engineering cycle time

Existing design data can be reused to create new designs

Quick design turnaround, increasing efficiency

### **Advantages and disadvantages of Parametric Modeling**

Why-Use-Direct-modeling tools are conducive for design tasks which involve strict criteria for manufacturing objects on a continuous basis.

#### **Pros of Parametric Modeling**

Automatic model updates whenever new changes are made

Easy capture of design intent for defining the behavior of the model conveniently

Automatic family creation

Superb integration with manufacturing processes; thereby resulting in decreased production time

#### **Cons of Parametric Modeling**

Parametric 3D Modeling can become heavy-handed during concept design; especially when designers are still exploring ideas

Updates take more time in parametric models in case of last-stage design changes

## Results

- ١-Parametric design takes inspiration from nature.
- 2- The parametric design emphasizes the importance of studying computer programs such as grasshopper, bim, raino and environmental analysis programs.
- 3- Parametric design has an important role in architectural environmental compatibility
- 4- Parametric design allows designers to achieve complete fluidity in all stages of design.
- 5- Parametric design represents the medium that strongly influences the emergence of new ways of digital design in contemporary architectural designs.
- 6- Parametric design not only affects the formal characteristics of designs, but also produces a new model of design thought
- 7- Parametric design has an important role in generating and discovering multiple design alternatives
- ٨-Flexibility and adaptability in the parametric design give it priority in choosing the designer.
- 9 - The use of parametric design in different stages of the design process during design and construction.
- 10- Parametric design has the ability to represent and model complex geometry shapes
- 11- Parametric design has an important role in performance design and in the application of modeling
- ٨-Parametric design has the ability to represent and model complex geometry shapes.

## Recommendations

- 1- The need for architects to draw attention to new concepts in architectural design and to use modern modeling programs.
- 2- Take advantage of the parametric design features in the architectural environmental compatibility.
- 3- Applying new methods of digital design in architectural designs.
- 4- The necessity of training students of the faculties of engineering and interior design on modern design programs such as Maya and Bellhopper to meet the requirements of the labor market.

## Conclusion

The rapid development of digital technology led to the entry of digital media into the world of architectural design, which led to the ease of designing architectural blocks that were difficult to express by traditional means.

Parametric design in contemporary architecture is an important design approach in the design process.

The architectural design techniques that accompanied the digital revolution and that affected contemporary architecture, represented by virtual reality techniques, dynamic modeling techniques and parametric modeling techniques, are clear.

Parametric design is concerned with finding a suitable design for all fields such as architecture, interior design, industrial design, and others.

### References:

- 1-Abdul-halim Jabr, on site Review Report ,published article,2016
- 2-Aish, R.,Woodbury,R..Multi-Level interaction in parametric design,2005.
- 3-Biloria, N.,Oosterhuis,K.,7Aalbers,C.,Design informatics: a case based on investigation into parametric design scripting and Cnc based manufacturing techniques.2006
- 4-Kat Park and Nicholas Holt, Parametric Design Process of a Complex Building In Practice Using Programmed Code. As Master Model .Kat Park and Nicholas Holt issue03,2014
- 5-Makis, Presences de l'architecture contemporaine (CDMC),2001
- 6-Rodrigo Garcia Alvarado, Jaime Jofre Munoz, The Control Of Shape: Origins Of Parametric Design In Architecture In Xenakis, Gehry And Grimshaw,2012