



“COMPLEXITY AND COMPOSITION IN CONTEMPORARY ARCHITECTURAL PARAMETRIC DESIGN”

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Abstract. Contemporary architecture is the architecture that represents the 21st century. Architects are working in different styles, from high-tech architecture to highly conceptual and expressive styles, resembling sculpture on an enormous scale. The different styles and approaches incorporate the use of very advanced technology and modern building materials, as well as, the use of new techniques of computer-architectural aided design.

Complexity and Composition in Contemporary Architecture incorporate a contingent assemblage of theoretical, practical, ecological, economical, political, social, and cultural parameters that presuppose the design and performance of architecture. Architecture affects these parameters. The role of architecture includes the effectiveness of sustainability. Contemporary buildings are designed to be noticed as landmarks of the place. The real complexity of architecture is an integration of parameters typified by architects integrating and practicing this complexity.

This parametric design is increasing complexity of building production increasing complex building technologies and envelopes, energy efficient techniques and technologies, software, fabrication and construction delivery methods, economic and ecological factors. Building design and building performance is a fundamental engagement with these multiple and complex contexts that condition the contemporary architecture. This parametric design strategy, which used computers for developing complex forms and construction of the buildings was often practiced in the projects of Zaha Hadid, Massimiliano Fuksas, Frank Gehry, Jean Nouvel, Daniel Libeskind. Specific attention in this research will be given to analysis of the usage of the parametric design as an algorithmic thinking that enables parameters and rules that, together, define, encode and clarify the relationship between design contents and design response. The expected outcome results in this scientific paper is to identify the contemporary design approaches and create application at the international education processes.

Keywords: contemporary; parametric; architectural design.

1. CONTEMPORARY ARCHITECTURE

Contemporary architecture is the architecture of the 21st century. Contemporary architects are working in different architectural styles, from postmodernism and high-tech architecture to highly conceptual and expressive styles.

The different styles and approaches have in common the use of very advanced technology and modern building materials and the use of new grtbrgtechniques of computer-aided design.



Figure 1. Contemporary Architectural Design and Parametric Forms in Architectural Design - Guggenheim Museum in Bilbao, Spain, arch Frank Gehry



Figure 2. Contemporary Architectural Design and Parametric Forms in Architectural Design - Baku Flame Towers Construction, Baku, Azerbaijan, Zaha Hadid Architects Spain, arch Frank Gehry

1.1 Complexity and Composition in Contemporary Architecture

Any building architectural project is an assemblage of theoretical, practical, ecological, economical, social, and cultural parameters that define the design and performance of architecture.

The real complexity of architecture is integration of parameters typified by architects integrating and practicing this complexity. Building design and building performance is in fundamental engagement with these multiple and complex contexts that influence contemporary architecture.

Contemporary buildings are designed to be noticed as landmarks of the place. Some feature structures have the following characteristics: very asymmetric facades, skyscrapers twist, or break into crystal-like facets, facades are designed to shimmer or change color at different times of day, in order to be presented as landmarks of the place.



Figure 3. Contemporary Architectural Design of tall buildings as landmarks of the city

Most internationally well known landmarks of contemporary architecture are works of a small group of architects who work on an international scale.

The parametric design strategy, that uses computers for developing complex forms and construction of buildings was often practiced in the projects of of the protagonists architects: Mario Botta, Frank Gehry, Jean Nouvel, Norman Foster, Renzo Piano, Zaha Hadid, Santiago Calatrava, Daniel Libeskind, Jacques Herzog and Pierre de Meuron, Rem Koolhaas, Bjarke Ingels, Massimiliano Fuksas, Peter Eisenman.



Figure 4. Contemporary Design of Gherkin Building in London, arch Norman Foster

2. COMPLEXITY AND COMPOSITION IN CONTEMPORARY PARAMETRIC ARCHITECTURE

Complexity and Composition in Contemporary Parametric Architecture incorporate the following dynamic architectural parameters that are positioned to be performed as concept in architectural parametric design:

1. Energy parameters,
2. Site parameters,
3. Climatic parameters,
4. Form parameters,,
5. Construction parameters,
6. Programmatic parameters,
7. Regulatory parameters,
8. Economic parameters, and
9. Social aspects of a project as primary parameters of the architectural design process.

This type of architectural parametric design is increasing complexity of building production increasing complex building technologies and envelopes, energy efficient techniques and technologies, effectiveness of sustainability, software, fabrication and construction delivery methods, economic and ecological factors.



Figure 5. Contemporary Architectural Design of London City Hall, arch Norman Foster

3. PARAMETRIC ARCHITECTURAL DESIGN

Parametric design is algorithmic thinking that enables parameters and rules to define, encode and clarify the relationship between design intention and response. Architects use digital technology in terms of defining complexity and composition in parametric design.

Christopher Alexander - in *Community and Privacy* started to set out 33 design variables for prototypical urban housing, which he organized (with the aid of 704 computers) into sequences of groupings.

This parametric design strategy, made the “insoluble levels of complexity”.

“This type of Synthesis of Form” described the analytic and synthetic model as a way to find sophisticated design methodology.

Parametric architecture is connected to algorithmic thinking: designing by explicit rules where the geometry and performance criteria are both mathematically and technically pre-rationalized with complex computation technologies.

This included computer packages like Grasshopper, Digital Project CATIA, Tekla, Inventor, and the use of SolidWorks, machines for fabrication and topographic survey machines on site for installation.

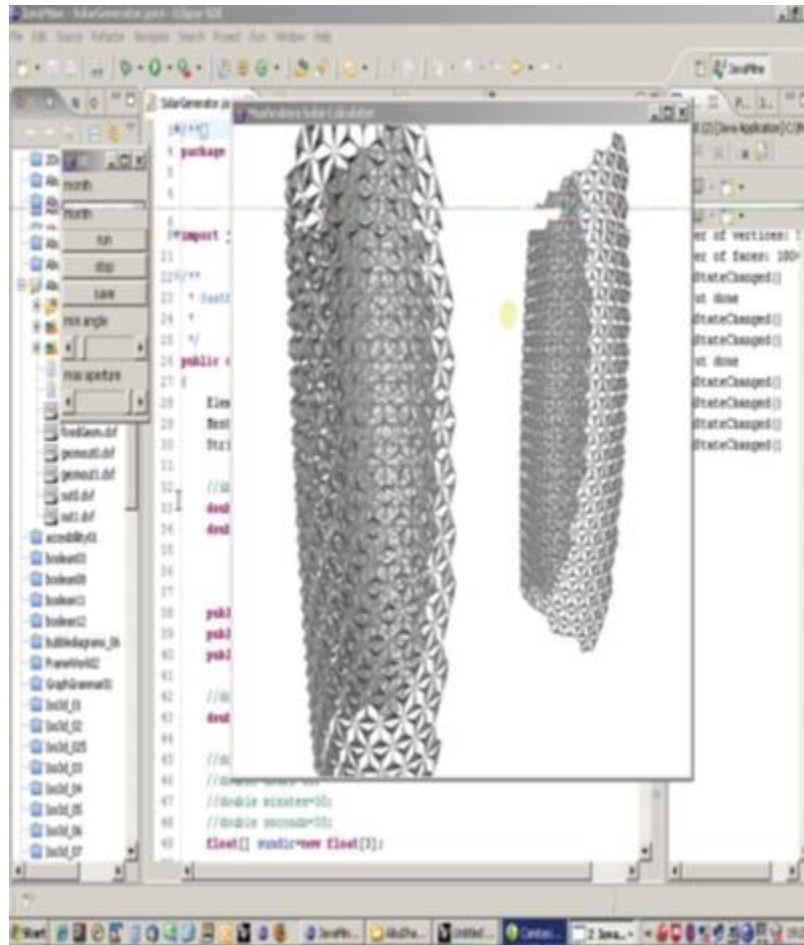


Figure 6. Algorithmic design process using computer platforms for parametric architectural design

4. PARAMETRIC DESIGN PARADIGMS

Contemporary design practices developed three different parametric design paradigms:

1. Parametric formalism that uses complex formal compositions as narrative in parametric techniques
2. Parametric BIM software and processes that allow architects and engineers to construct virtual models for the building systems and materials
3. Workflow parametric using parametric features to automate specific design workflows for projects such as façade design, environmental processes or structural procedures

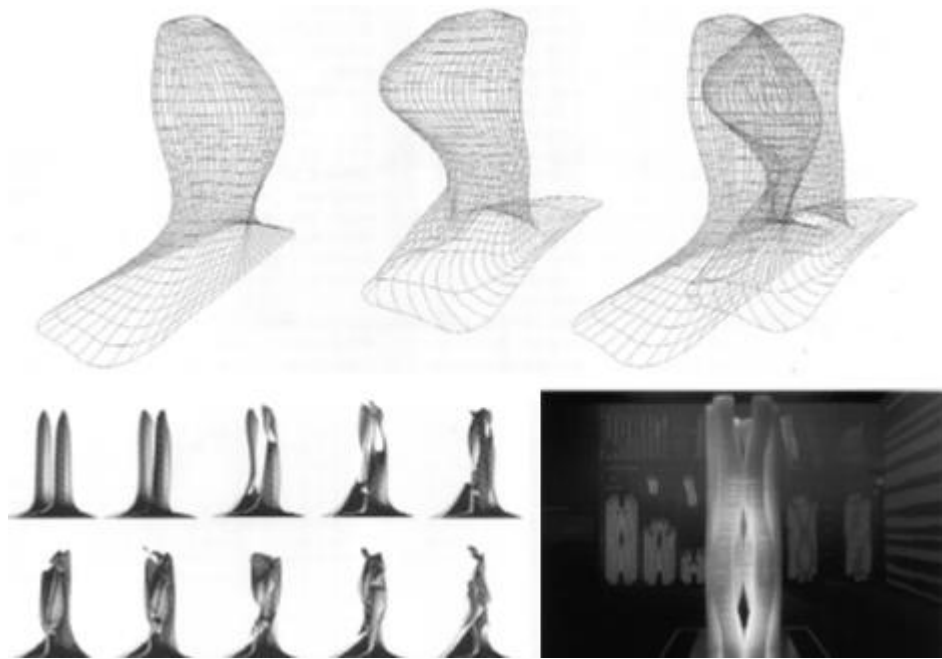


Figure 7. Geometric Design Method Analysis of Parametric Architecture

5. GEOMETRIC DESIGN METHOD ANALYSIS

The structure of the tall building exemplifies the approach in engineering, so that the central core supports much of the weight of the structure and load. Floor plates and beams connect to central core to surrounding exterior columns, each conducting a small part of the load to the ground and preventing the building from overturning or sliding when exposed to strong lateral forces such as wind and earthquake. The horizontal structure of the floors brace the entire building by tying inner core and outer frame together.

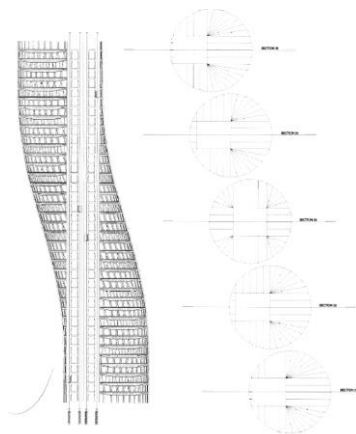


Figure 8. Geometric and Structural Analysis of Parametric Architectural Design

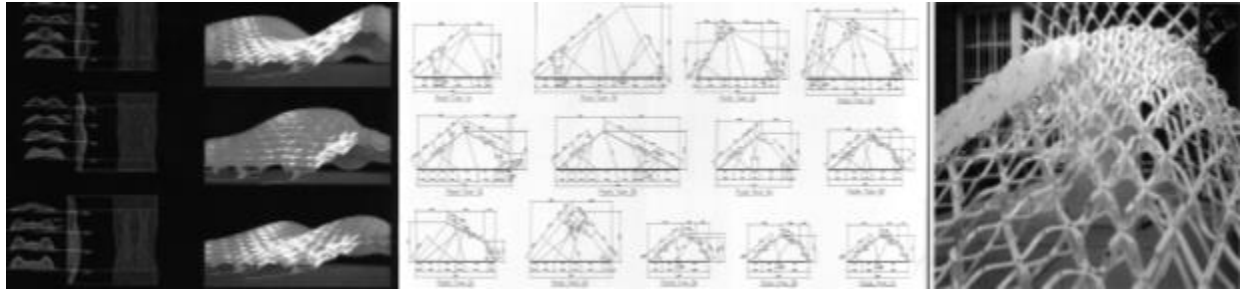


Figure 9. Engineering Complex Geometries, Algorithms and Complex Patterns in Architectural Design

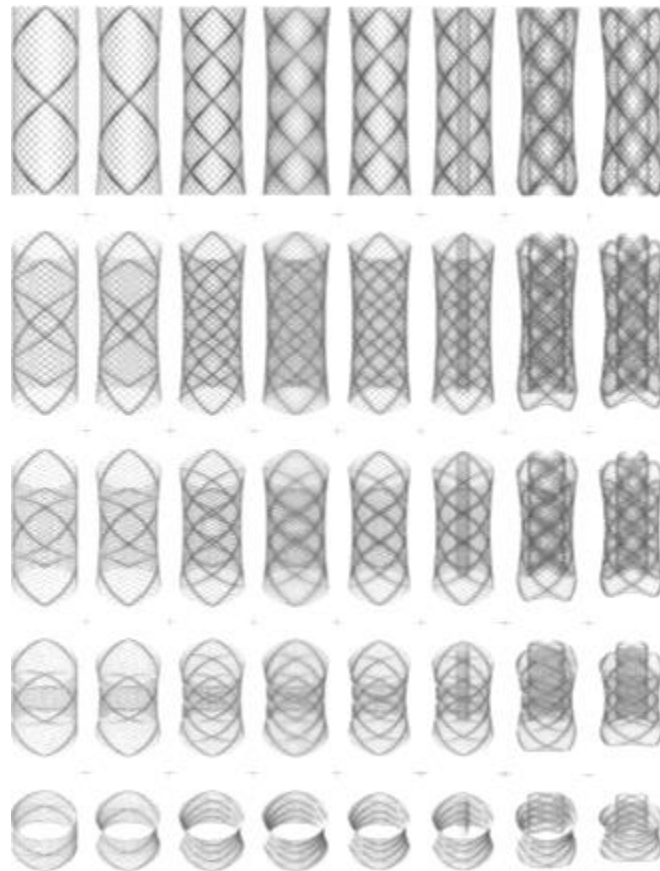


Figure 10. Architectural analysis of development of form of evolved double-helix structure

Phenotype Development by exposure of the geometry to environment in parametric design creates forms that increase structural capacity by sharing and distribution of loads.

The building envelope In the architectural design is an integral system of structure and environmental panels that adapt to the geometry and performance of the building.

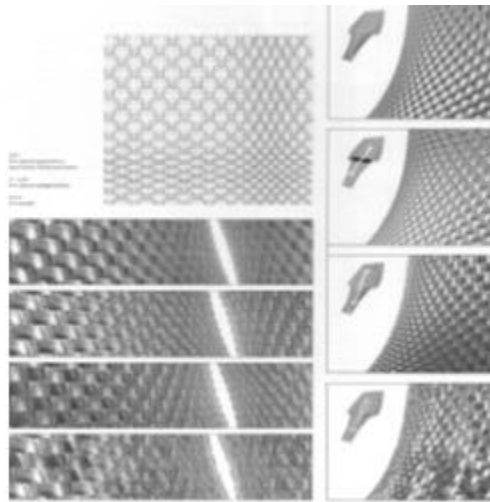


Figure 11. Phenotype Development by exposure of the geometry to environment

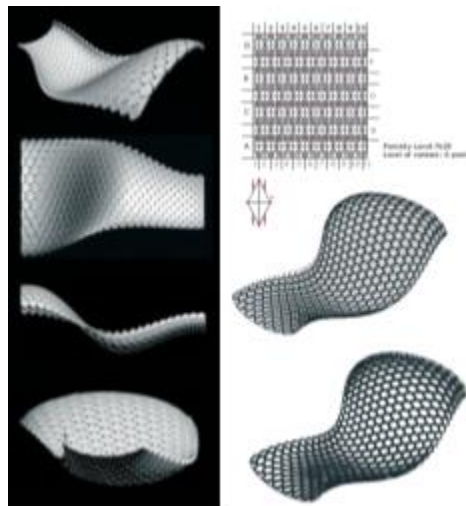


Figure 12. Parametric defined and varied digital model of double curved brick assembly

6. PARAMETRIC DESIGN PARADIGMS – GREEN DESIGN AND SUSTAINABILITY

Parametric design for modeling of integrated systems in architectural and urban scales:

- Architectural parametric design has a growing interest for the architects and engineering in designing exterior skin assembly and shapes of the building as a geometrically complex, net-zero-energy buildings, sustainable architecture,

- Urban parametric design focuses on sustainability issues (especially in the design of the infrastructure systems related to energy and water of the cities).



Figure 13. Architectural Parametric Design, Azerbaijan Cultural Centre, Baku, Azerbaijan, Zaha Hadid Architects, 2011

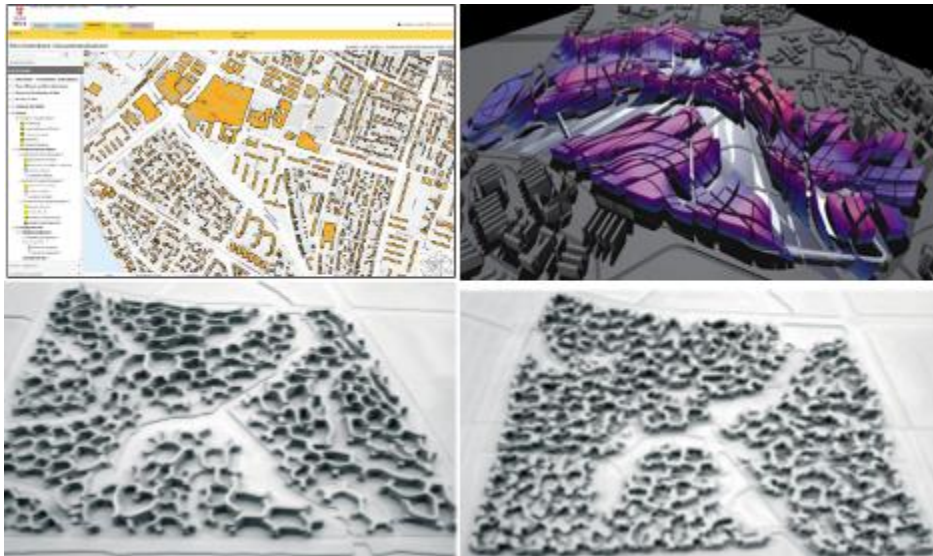


Figure 14. Urban Parametric Design - Modeling of urban infrastructure systems. Modeling software, showing resources for a proposed urban design project - Online Solar Cadastre of the City of Vienna and Urban Parametric Design

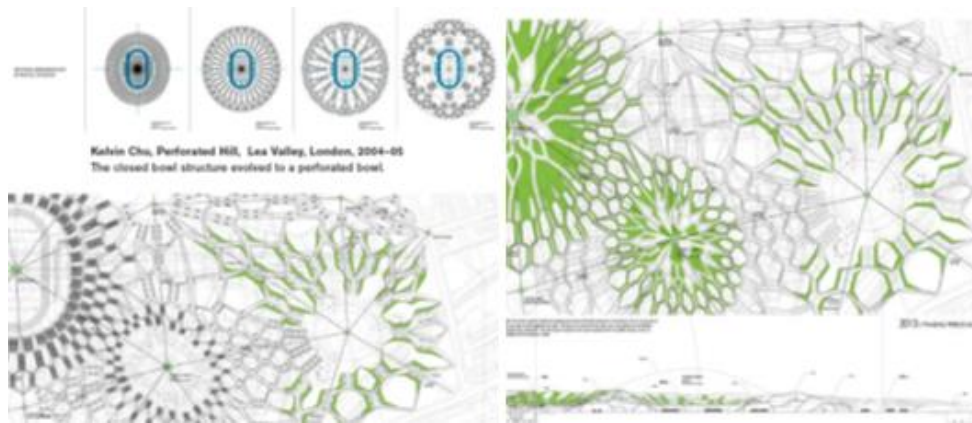


Figure 15. Urban Parametric landscape design, Perforated Hill, London - Modeling of urban infrastructure and landscape design. Modeling software, showing resources for a proposed urban design projec

Parametric design is part of prefabrication construction that plans sustainability, environmental concerns, design performance, material savings of quality products. The complex parametric design focuses on curvilinear geometries rationalized into curtain wall cladding systems.

The structural systems (including the floor slabs, perimeter columns, and sub-structural components) are designed by using algorithm design of the curtain wall system. This concept of prefabrication use can be seen in post-parametric automation in design and construction of complex buildings.



Figure 16. Urban Parametric Design and Architectural Design - Zaha Hadid Architects, Changsha Meixihu International Culture and Art Centre, China

The referent example of parametric architectural design concept of building Al Bahr Towers in Abu Dabi, Dubai responds to the fundamental issues affecting the standards of a fully glazed building in a hot climate and solves this challenge with the integration of a facade based on the traditional Islamic mashrabiya, a lattice screen used to diffuse sunlight while keeping buildings cool. Architectural designed visual code creates set of pattern and structural morphology into a telling language, social and communication aspects as semiological project. Parametric Architectural Design is complex of traditional geometric composition, sustainable technology and bio-mimetic concept, as a quantitative tool for creating biomimetic design in terms of sustainable concept of architectural design.



Figure 17. Parametric Architectural Design¹, Al Bahr Towers in Abu Dabi, Dubai, 2011

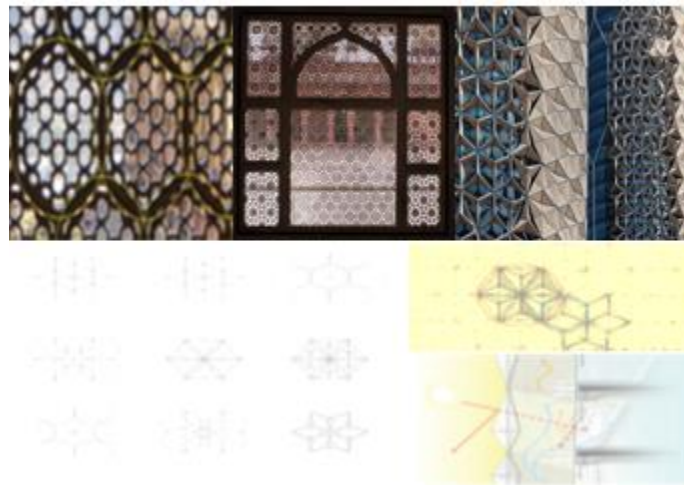


Figure 18. Architectural designed visual code creates set of pattern and structural morphology into a telling language, social and communication aspects as semiological project²

Parametric Design can be often used as a principle in modern contemporary interior design in shaping ceilings, flooring and often in furniture design. This principle of parametric design is often combined with wooden structural systems that are shaped in a specific algorithmic parametric design.

¹ Parametric Architectural Design is complex of traditional geometric composition, sustainable technology and bio-mimetic concept

² Concept of the shading screen patterns inspired from the Mashrabiya from the traditional architecture and natural adaptive systems



Figure 19. Parametric Architectural Interior Wood Design in Furniture, Wall, Ceiling Decorations

The world's largest parametric interior design in the world is the modern architectural parametric interior design of the Turkish Airlines Lounge in Istanbul Airport, from Avci Architects, located in Istanbul, Turkey. The concept of the Flow wall from Turkish Airlines unites the lounges in Istanbul Airport creating a flow concept of 19 000 square meters intuitive route with architectural space, symbolizing connecting people, culture and places. The architects studio used parametric design algorithm-based process which allowed them to test various outcomes of the design concept within a set of parameters.

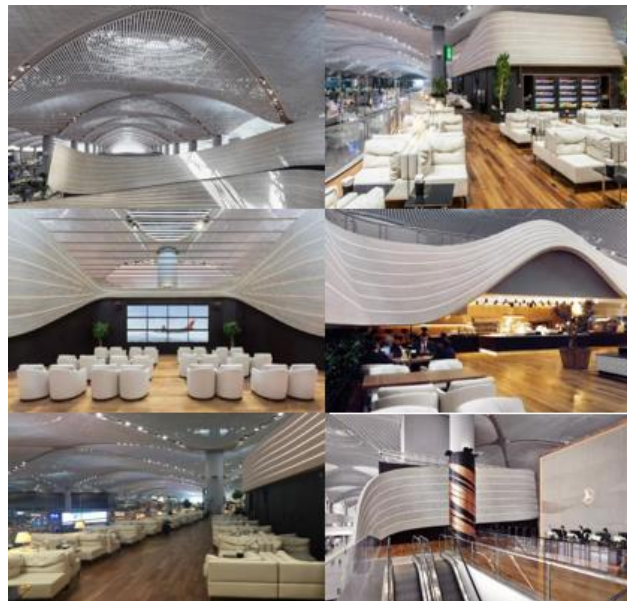


Figure 20. Modern Architectural Parametric Interior Design - Turkish Airlines Lounge, Istanbul Airport, Avci Architects, Istanbul, Turkey

The referent example of TAV Airport in Tashkent, Uzbekistan also presents architectural awarded project for parametric design concept. The concept design was inspired by traditional Uzbek architecture, the abstract colorful geometric patterns which have been shown as a stylization of forms in modern shaped architectural and interior design. The architectural design suggests linked space in order to unify, where the canopy acts as unifying element of the design, linking the roof of the building and the plaza by its dynamic and fluid form which also corresponds to the function of the building.



Figure 21. TAV Airport in Tashkent, Uzbekistan, Architects: Pinar Ilki, Dicle Demircioglu

7. CONCLUSION

Parametric design in architectural design studios emerges from the concept of new engineering and fabrication methods in a stylistic form-based and optimization processes towards new contemporary style in architecture.

Semiological articulation of parametric architectural design can map significant programmatic and morphological conceptual distinctions.

Engineering ecological concept and paradigm start to shift, in a concept that incorporates contemporary design as a modulation of environments and ecologies in architectural parametric design of the 21st century.

Parametric design is creating large number of architectural and engineering concepts which transform their practices by using parametric, BIM, and parametric automatization design tools towards a new contemporary complexity and composition in a new trend of parametric architectural design.

The current trend from engineers for prefabrication and modularization will focus on development of 3D multi-materials and synthetic biology processes for different types of new bio-materials designed at micro and nanometer level to respond to the particular conditions according to the needs of the parametric architectural design.

This concept of parametric design in architecture will lead into contemporary transformation of the design and traditional design process of the next generations of architectural engineers of the 21st century.

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