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The Effect of Technology to Integrate Aesthetic Desire of Contemporary Architecture with Environmental Principles in Façade Design*

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Abstract— As architecture continues to express itself in the way form is created, the application of a building's skin has shifted from pre-Modern ideas of applied Ornamentation, to the intentional abolition of ornamentation in Modernism (~1920s), and has reappeared in Postmodernism (~1960) and present day Architecture. The advent of the digital era has introduced new tools that provide parametric design of building skins. These skins however, largely tend to be an aesthetic expression of form (or ornament), and rarely meet environmental conditions such as effective radiation control, day lighting or thermal comfort. On the other hand, environmental crisis and interior air quality of buildings has provoked the criticism of the buildings since 1970. in current era, human being are still in a critical condition in terms of energy consumption, so designing a building that incorporate economy of energy consumption and building environmental protection, is one of the main responsibilities of architects. Facade as a building skin, that is an interface between interior and exterior condition, play an important role in building energy consumption and its interior comfort. Historically, there have been different solutions such as reflective glasses, shading devices and…, applied to building's façade, to address environmental issues but none of them can meet aesthetic desire of contemporary architects. The building skin, as both the building's interior and exterior interface and as the Architect's statement, must be designed in such a way that could address different set of needs. Accordingly, in this study, It is aimed to determine how new technologies can contributed to a synthesize of formal and environmental needs in the contemporary architecture This research focuses on some case studies and uses analytical descriptions techniques and library documents to determine the impact of technology on environmental and aesthetic needs of contemporary architecture. Results show that new digital tools and technologies have introduced new tools to architects that smooth their design process and allow them to think of different complex forms modeling, their environmental optimization and even their fabrication after design process. Therefore, Architects can implement their formal ideas while complying with the environmental principles, using new technologies.

Keywords—Facade; Environmental design; Aesthetics; Digital age; Parametric design

I. Introduction

since1970, Energy crisis and indoor air quality have prompted criticism of buildings. Subsequently, in late 1980 and early 1990, environmental design issues have been seriously and academically addressed in order to create energy optimized buildings and also solutions that can be a suitable response to climate changes [1].Façade as part of building structure play an important role in sustainable building`s design. However, some architects just pay attention to aesthetic aspects of a building façade and ignore its capacity to protect the building from environmental agents.

The ever present climatic crisis coupled with increased environmental regulations has created the necessity for increased integration of formal design with sustainable practices. As a result, the building skin, as both the building's primary protection from the elements and as the Architect's statement, must be addressed and better implemented into design to address increasingly complex sets of needs [2].The building skin perform the role of an environmental filter between interior and exterior conditions, while addressing and resolving a wide spectrum of issues such as technical performance, visual appearance, ventilation, assembly, etc. [3]. The use of technology to Design and build constructions with respect to their conditions and situations is considered to be a novel and particular concept in modern architecture. The accurate and appropriate use of technology can result in the creation of perfect and flawless buildings. Hence, the sensible use of technology along with the application of local civilization is the resolution to the current challenges in architecture [4]. The ongoing change of technological paradigm has great consequences for the production of architecture. New technology makes long series of identical

elements obsolete, industrially produced components can be unique and optimal in the construction. Also, digitally governed production could foster new modes of meaning creation. New conceptions and definitions of objects are emerging with parametric design [5]. Digitally driven design processes characterized by dynamic, Open-ended and unpredictable but consistent Transformations of three-dimensional structures are giving rise to new architectonic possibilities [6]. Even though the first years of experimentation with digital techniques within architecture in many ways focused on aesthetics and generation of form, there are strong tendencies in architectural conceptions based of parametric design to look more to functionality than isolated form. The use of parametric design makes it possible to contextualize the architectural object and make it Adjustable and variable to the situations in where it shall function. [5]
This paper discusses consequences of new digital tools and technologies for integration of two major concern of today's architects, environmental an aesthetic aspect of building façade.

II. Statement of issue

The progression of style from traditional to modern architecture and now contemporary architecture has resulted in a deficiency of incorporating sustainable techniques in building design [2]. On the other hand, energy crisis and environmental issues are one the main concerns of today world.
Regarding this problem, the main question of this paper is that how digital technology can contribute to the integration of aesthetic desire of façade designing with environmental principles?

III. Methodology

Based on the research question, our paper proposes to use descriptive method. It uses analytical-description techniques and library documents.

IV. Façade role in building

Building Façade play two important role in buildings:
1-introduction to building's identity and its context: in this role, facade aesthetic facet should be taken into consideration. Façade not only establish its own identity but, in urban scale, form urban identity. So it should be consistent with its context and also improve urban environment. To a great extent, cities appearance is under the sway of their building's façade .indeed facade can be considered as the intersection point of architecture and urban design that make it an important element of building.
As a visual context, cities have great influence over citizens so, regarding this fact, an unfavorable and inappropriate appearance of urban façade can also have a destructive mental effect on citizens [7].
2-a mediating element between inside and outside of a building: building's façade along with its windows, control energy transfer between inside and outside of the building and protect building interior against exterior agents.also.it provides natural light , vision to building outside and consequent visual and thermal comfort. So, careful selection of building façade systems to ameliorate urban environment can also bring about occupations comfort and abate energy consumption that is a universal need [8].

V. A brief Review of Façade during the history

Building skin as an important part of the building has a history as long as architecture history and Most of the cultural, social, political and religious manifestation of civilizations is in debt of it. In order to understand architects' attitudes toward façade in different historical period, a brief review of it in pre modern ,modern and post modern period is presented.

A.pre modern era

The art of classical period is associated with the creation of human sculpture and also classical orders that can be easily determined in its columns, appearing inside and outside of the heir buildings. For Vitruvius and all those who followed his documentation of the classical style, ornament and design itself revolved around imitation. Strict rules were set up regardless of the context of a given site, the technology available at a given time, or the functional requirements for a given client. These rules effectively stopped innovation because preconceptions (having solutions before even seeing the problem to be solved) prevented harmonious ornamentation of all the parts [9].
The architecture of middle age was shaped by a range of different factors, changes in the nature of Christian worship, political ideologies, shift in aesthetic sensibilities, improvements in the professional skills available to patrons, etc. churches were the product of ideological changes .The beauty of these early churches was derived from its interior space and decoration rather than its exterior. In this age, following the collapse of Roman Empire in the west, the decline in both skills and resources made it difficult to emulate classical style, but with the Renaissance came a renowned and a deeper interest in the past [10].Renaissance design style belongs to the period between15th and17th century in different region of Europe, where there was a conscious revival and development of certain elements of ancient Greek and Roman thought and material culture. In architectural design, the Renaissance style put an emphasize on geometry ,symmetry , proportion and the regularities of elements .orderly arrangement of structural elements such as columns and lintels replaced more complex proportional systems and irregular profiles of medieval buildings [11].
Generally in pre modern era ornamentation was of great interest to architects either in building interior or exterior.

B. Modern era

During the last two decades of 19th century, the first examples of modern buildings, without any trace of history and ornamentation were constructed. In this period, high-rise buildings were established with steel structure, non-bearing walls and extensive windows. Considering design and construction methods and also architect s theoretical principles that are the first charter of modern architecture in this period, following characters can be deemed: appearance of building structure in its façade, absence of historical style, little use of ornamentation and also broad windows, traversing between two columns [12].

Although the contemporary style developed into many different trends all over the world, basically it can be characterized by having abstract details, plain surfaces and highly elaborated geometrical forms and materials [11].

One of the important issues in this period was industry and industrial products and also new technologies that all architects were, in some way, obsessed with it. In this periods, some architects were trying to break off architecture's connection with the past and historicity .Instead, they proposed to substitute technology and functionality as a source of inspiration for architects.

Overuse of new technologies such as glazing and deliberate elimination of ornamentation in modern architecture lead to a kind of international architecture .based on this new style, a building lacks any regional and local characters like industrial products [12]. Glass, as a material that was being produced by developing industry in a promising way, was favored by most architects as a light and transparent material that was greatly suitable for simplification in works of such architects as Mies van de Rohe [13]. With a surge in application of glazed facades, the need for efficient control instrument for environmental condition of building's inside increased. This measure, not only increased the need for artificial devices to create occupants comfort, but also changed the appearance of these buildings [14].

B.post modern era

In late 1950s, international modernism, which had dominated architectural discourse and was represented in important buildings, constructed immediately after World War II, was gradually being undermined. In place of white stucco, steel and glass, flat-roofed buildings that had their origins as a European style in the 1920s and 1930s, buildings appeared that were decorated in bright colors with pediments, round windows and classical-like columns and pilasters [15].

Charles Jenks, one of the famous architectural theorist and critics, believes that Post modern architecture is a n expression of connection between the past and present. In Jenks point of view, architecture is depended on ornamentation and patterns .also, architecture should demonstrate social realities of today's city and it ought to respond to ecological agents. .Robert venturi, one of the major architectural figure in twentieth century, like Jeknz, is not interested in a pure and clear style that lacks vivacity and allure, but he supports provisions that based on them, buildings are constructed in consistent with costumers need and local conditions[16].he spurn technological view of modern architecture and instead ,he desire an architecture that favor human characters and pay attention to humankind. He believes that architecture is not just technique and technology but it incorporate different complex and conflicting issues that cannot be ignored or eliminated [12]. In his book,' Complexity and contradiction In Architecture', he restates ornamentation in architecture and represents a new definition of architecture, based on ornamentation. Venturi, in his book, affirms that architecture is a building with ornamentation on it. Actually, what can be seen on building's façade of this architectural tide, in practice, is the combination of the past architectural patterns with present architecture.

VI. Digital age in architecture

If , in modern era, glasses were known as new technologies and could revolutionize architecture, today new digital devices and intelligent technologies has sparkled great changes in architecture that has altered expectations from architects. There is a fact that whenever a new technology emerges, new architectural styles and movements appear. New technologies create new literature in architectural world such as computational design, parametric design, digital architecture that are the result of digital technology emergence in architectural world.

Gradually, with the advent of these new digital technologies in architectural world, since 1960, architectural design has been exposed to many changes and form has developed into complex forms that almost there is no limitation for their construction. Actually, computers and digital tools have a significant role in ambitious and highly-articulated form design and also facilitate different evaluation of a building in design process [17].also, The Digital era has radically reconfigured the relationship between conception and production, creating a direct link between what can be conceived and what can be constructed. Building projects today are not only born out digitally, but they are also realized digitally through "file –to factory "process of computer numerically controlled (CNC) fabrication technologies [6].

In digital design software objects are no longer designed but calculated, and two great possibilities by the use of parametric functions is delineated. First, it involves a changed mode of conception that allows complex forms to be designed that would be difficult to represent by traditional drawing methods. Second, these parametric systems lay the foundation for a nonstandard mode of production, where the modification of calculation parameters allows the manufacture of a different shape for each object in the same series. "Thus unique objects are produced industrially [5].

In this period, some architects are experimenting with digital tools to generate and construct novel forms and innovative design procedures, others to help with an overwhelming number and complexity of variables in environmental design.

Actually, there is a divide between those Practicing environmental design, and those experimenting with digital form finding and generative design. [18] But, in new generation of digital tools, they can be implemented along with each other. Actually, In a digitally generated model, a virtual model is built in a computational virtual environment in such a way that real world condition and its needs such as environmental needs can be tested and also such virtual prototyping is less time-consuming as against a physical prototyping.Virtual prototyping and current simulation technologies are used to evaluate performance of the design prototype, mainly for product development, manufacturing and construction purposes .such simulations are based on quantitative and analytical results, and can vary from visual analysis to various engineering analysis ,simulations, testing temperature, behavior under physical conditions, etc[19].

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VII. Design of building façade in digital era

One of the main elements of building, constituting its identity, is building‘s envelope. Much in the same way as buildings volume that manifests building’s identity from a distance, building cladding also state buildings identification in a closer view. Building cladding can establish a unique identity for building volume. Fig2

Fig.1. Spain Pavilion in Expo 2010

There are some complex geometries that their execution in practice is daunting and sometimes impossible, so to address highly articulated geometry, the application of modeling soft ware which produce numeric data for construction phase is inevitable. Not all digital tools provide a scientific environment for design and manufacturing process. Some initial examples of such digital soft wares as sketch up and 3d max just present an image of building volume. But in newer generation of digital tools that provide parametric and algorithmic design,instead of designing a fixed geometry ,a flexible parametric product can be generated .this product can be reconfigured by changing parameters. in other worlds ,different model can be acquired ,using a basic algorithm .

These software are an scripting environment in graphic soft ware such as Grass Hopper or Rhino script that are a plug in of Rhino ceros, or Formian that is an independent script language.

a simple example of parametrically defined pattern is demonstrated In Fig.2. This pattern ,defined by a basic parameter, can be changed to produce different patterns. The selection of parameters can be implemented in different ways and even more than one parameter can be defined to create various patterns .indeed, Parametric modeling makes designers able to delineate the relations and proportions of basic pattern parts in order to produce their desired pattern with the same proportions but in different scales

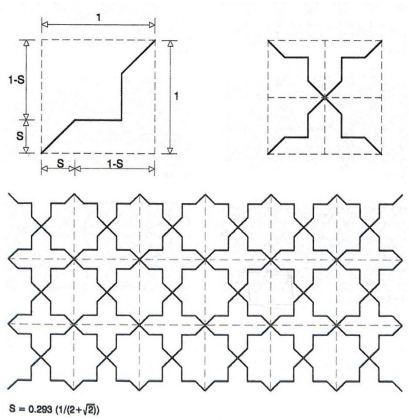

Fig.2.a basic pattern defined parametrically

With changing the defined parameter(s), different patterns are generated.Fig.3

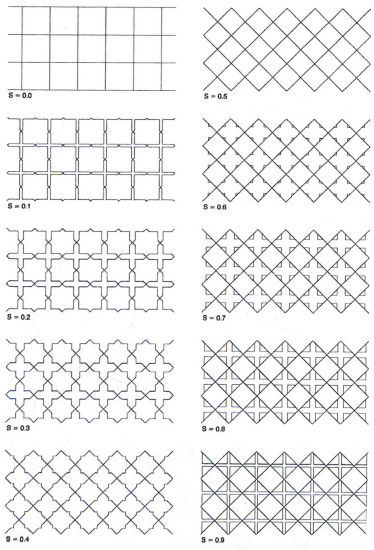

Fig.3.different patterns derived from the basic pattern

These Defined parameters can also be manipulated in response to different criteria such as temperature, sun direction, etc, using energy simulation tools in the same modeling environment.
Not only an environmentally optimized form can be produced but also it is possible to create patterns that reconfigure itself in response to environmental condition. In such a sophisticated facade, environmental data are received via a range of building sensors, then theses data are transmitted to a central processer to be processed and appropriate instructions are delivered, then façade pattern change its configuration according to processor instruction.

VIII. Case studies

In what follows, some projects are orderly introduced, based on the effect of digital tools on façade designing, the first example just mention a formal use of digital technology, but in following sample, both formal and environmental factors are regarded. The final example demonstrated a sophisticated use of new digital and intelligent technologies that integrate environmental and aesthetic desire of current architects.
Marsa tower in Dubi that is designed by Zaha Hadid show a formal influence of new digital tools.Marsa residential tower façade was confined to have just 40percent opening that was determined by structural group. Zaha Hadid proposed solution was to use a parametric pattern for building skin that its opening grows while building rise upward. This solution not only contribute to a better understanding of geometrical pattern but also increase the structure efficiency due to the large opening position on higher part of the building[17].Fig.4.

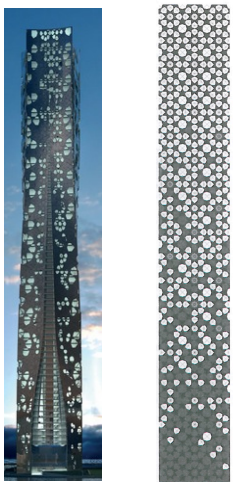

Fig.4.Marsa residential tower

Although The first years of experimentation with digital techniques within architecture in many Ways focused on aesthetics and social aims, some new generation of buildings shows that digital design can have a more in depth application in architecture .it transforms architect view beyond formal issues and let architects to consider main parameters ,resulting in buildings efficiency.

A remarkable example of such buildings is Sino steel project in China.Fig.5. This project comprises a 358 meter long office building and a 88 meter long hotel adjacent to office. Windows of office building are designed in a natural and irregular pattern like different cells. Although its pattern, at first sight, seems to be randomly arranged, it is exactly organized in response to sun position and wind direction in relation to building .by mapping windflaw and sun radiation in different direction, the dimension of façade openings are determined. This method minimizes heat dissipation in winter and heat absorption in summer.

Fig.5.Sino Steel tower

another case study demonstrate the effect of technology on building skin in a more sophisticated level than previous ones. This example shows an integration of contemporary architects' ambitious ideas with environmental principles to optimize their ideas in an adaptable way .This interactive facade, reveal a culturally contextualized facade that respond to environmental criteria.

Adaptable systems synthesize the best strategies: the reduction of energy consumption and environmental control of building. For example, if façade in designed in such a way that can respond to temperature daily fluctuation, building energy consumption will significantly reduce. [17]In looking to innovative high-rise design, nature and culture are the most resilient sources of inspiration. The Al Bahar Towers.Fig.6 relies on both of these in the execution of the advanced screening system which was designed to integrate the building with its cultural context and respond directly to the climatic requirements of the region. The "Mashrabiya" form of the screens directly anchors the buildings in the Islamic tradition of the Middle East, while the dynamic movement of each of the individual units recalls the response of native plants. The use of highly developed modern technological methods facilitated this approach, through the use of parametric and algorithmic modeling. Pushing the envelope in terms of computing capabilities, the design concept was refined without sacrificing the ideals of the project. In the end, a new paradigm has been created in the innovative design of tall buildings [20]. The shading system developed by Aedas1 for the "Al Bahar" towerProject consists of a secondary skin of 1,000 "umbrellas" that "mediate light and reduce glare" on the east and west facades, according to the architects. Such

devices are necessary for thermal regulation of buildings in extreme environments [21].

Fig.6.Al-Bahar tower

A relatively clear glass curtain wall forms the "weathering" layer of the towers' skin. A secondary veil comprises intelligent automated shading components that open and closes according to the sun path. The shading veil acts as a dynamic 'Mashrabiya' (wooden lattice shading screen particular to the Middle East). The dynamic screen will reduce solar heat gain/glare and distort the image of the surrounding view [22].panels driven by a linear actuator will progressively open and close once per day in response to a pre-programmed sequence that has been calculated to prevent direct sunlight from striking the façade and to limit direct solar gain to a maximum of 400 watts per linear meter. The entire installation is protected by a variety of sensors that will open the units in the event of overcast conditions or high winds. The effects of this system are comprehensive: reduced glare, improved daylight penetration, less reliance on artificial lighting, and over 50% reduction in solar gain, which results in a reduction of CO2 emissions by 1,750 tons per year [20].

The façade system challenges the typical high-rise typology of the area, suggesting that more responsive and dynamic solutions to climactic conditions are more appropriate than attempting to statically handle them through designs based on non-regional traditions. Al Bahar Towers seeks to provide both a contextual and culturally sensitive design while also utilizing modern technology to meet higher standards of efficiency.

The design of the Mashrabiya façade's physical structure and the behavior was shaped by parametric technologies and processes. The architects wrote algorithm to describe the geometry of Mashrabiya façade within traditional CAD systems. Immediately after, during the development stage, the definition of the mechanical and kinematic details of the modules demanded a more robust approach. Parametric modeling environments were key to develop the proof concept critical to advance the project. An important aspect of this stage was to parametrically capture the movement of the module from the open to the closed states.Fig.7. The parametric modeling team iterated over the module's design with architecture and engineering teams until reaching an optimal solution. At the module level the team of BIM consultants developed detailed parametric models to account for the unique motion of the components. At the facade level the by-product of the parametric model allowed studies to be conducted to test the lighting performance, energy performance, and the facade's open vs. closed optimization. These studies fed back to the module, helping designers realize how even very small changes in the module—perhaps of only a few millimeters—affected the overall energy performance of the facade [23].

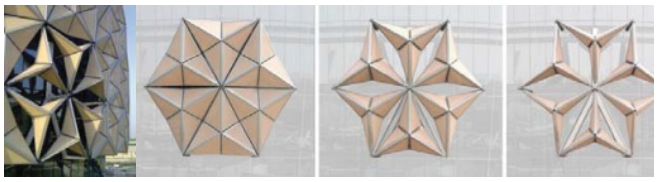

Fig.7.diffrenet stage of modules

IX. conclusion

Consequently, in this new method of design, different parameters of buildings are defined In virtual environment, then these parameters that are defined in relation to designers principles such as environmental principles can be manipulated to produce an optimized pattern.

The world of digital architecture, derived from digital technologies, support the implementation of architect's different ambitious ideas from its initial phase to its production and let architects carry out a wide range of simulation, concerning environmental agents.

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REFERENCES

[1] concalves.Joana Carla SoaresT. The Environmental Performance of Tall Buildings (1st ed),UK,Earthscan,2010

[2] Omidi far,Azadeh (2011), Design Optimization OF A Contemporary High Performance Shading Screen- Integration of 'form 'And Simulation Tools, Proceedings of Building Simulation 2011:12th Conference of International Building Performance Simulation Association, Sydney, 14-16 November.

[3] Lovell,jenny.2010.Building Envelope:an integrated approach.New York: Princeton Architectural press.

[4] Saeideh Feizi Azarshahr, Alireza Motamadniya, Mostafa Basiri. New Technologies in Modern Architecture and its

[5] Nilsson, F. (2007) "Architectural Objectiles – Architecture, form, meaning and experience inthe digital era". Architecture & Phenomenology International Conference. Proceedings CD

[6] Kolarevic.(Ed).2005.Architecture in the Digital Age: Design and Manufacturing.New York:Taylor and Francis

[7] Samira Garshasbi(2013),the study of identity crisis in residential building façade and its dimentions,proceedings of iranian national conference on urbanism and architecture,2013

[8] Iranmanesh,Mohsen (2004),The consideration of Nano technology in building façade design,A thesis for Master Of Architecture,Tarbiyat Modares University,Tehran ,Iran

[9] Gisbon,Fredric(1997), Beauty In Architecture Through Ornamentation,http://gibson-design.com/forum-BIATO.html.(visited on july2014)

[10] Roger Stalley(1999), Early Medieval Architecture,england,Oxford Uiversity press,(1999)

[11] Casakin,Ernan and Mastandrea Stefano(2009),Aesthetic Emotions and the Evaluation of architectural design styles, proceeding of international conference on engineering and product design education ,10 &11 September 2009

[12] Ghobadiyan,Vahid,Theories and concept in contemporary western architecture(6th edition),Iran,Cultural Research Bureau,2007

[13] Mozayeni,Manuchehr.Of Time and Architecture(3th edition),Iran,shahidi press,2007

[14] Hansanuwat.Ryan,Kinetic façade as environmental control system:using kinetic façades to increase energy efficiency and building performance in office buildings,Master of building science, University of southern California,America

[15] Sarfatti Larson,Mgali,Behind the Postmodern Facade: Architectural Change in Late Twentieth-century America,America,University of california Press,1995

.

[16] Bani MasudAmir,Western architecture:Roots and Concepts(5th Edition),Iran,architectural art of the century publication,2010

[17] Golabchi,Mahmood,Digital atchitecture(1stedition),Iran,Tehran University press,2011

[18] Hagan,s.Digitalia:architecture and the digital,the environmental and the avant-garde,london:routledge.2008

[19] Brandon,Peter,virtual Futures for design,construction &procurement, ,USA ,blackwell publishing Ltd.2008

[20] Council on tall buildings and urban Habitat ,www.ctbuh.org (visited on December2013

[21] Marroquin, Henry, per formative Parametric Design of Radiation Responsive Screens, Proceedings of the 2013 ARCC Spring Research Conference,

[22] Desmena2009, http://desmena.com/?p=1289.com,(accessed:2012/7/24)

[23] BIM2011, http://www.bimjournal.com, (accessed: 2011/7/24

[24] [6]Fox.Micheal& Kemp.Miles.Interactive architectiure (1st ed), princton architectural press, Newyork, 2009

[25]

[26] Interaction with Traditional Architecture. Res. J. Chem. Env. Sci., Vol 1 Issue 3 (August 2013): 70-80