Advanced Techniques In Design Openings Of Smart Facades In Buildings

Abdula Abdulrhman Alsarraf, Maysaa Moffeq Alobaidi

Department of Architecture Engineering, College of Engineering, University of Mosul, Mosul/ Iraq

Abd.88sarraf. @uomosul.edu.iq, maysaa.moffeq @uomosul.edu.iq

Abstract. During the present century, Architecture has concurrence great progress in the field of construction, methods and means of implementation used for the service of architecture, and the use of advanced building techniques is a building with adequate technical and appropriate support to maximize the functions and comfort of occupants with a compromise to reduce operating costs, Where designers used the potential of modern technology to design different parts of the building, including the building’s facades as part of the building that achieves environmental balance between the building and the surrounding environment, the research aims to discuss the advanced techniques used by designers in the contemporary interfaces openings in buildings, by building a theoretical framework for global studies in employing the latest technological techniques in architecture and touched on the practical study of computer simulation to handle openings on the facades of building.

Keywords: Advanced techniques, openings, smart facades, buildings.

1. Introduction

The advanced technology offered enormous solutions and potentials in the development of engineering fields such as architecture. The technology provided advanced solutions that designers and architects have benefited from in finding developed buildings adapted to their environment and creating new forms and ideas for these buildings and thus developing the building covers and their facades. The research discusses the most advanced solutions provided by smart buildings in the design of building openings, as smart buildings one of the most important models of advanced architecture in the twenty-first century.

2. Smart Buildings.

Smart buildings are defined as buildings characterized by their design and information technologies: responsiveness, flexibility, adaptability to changing needs with users and with systems that occupy them throughout their lifetimes, and supports communication between human systems, equipment, built-in communication systems, remote sensing devices and engines.[1] Provides a productive and cost effective environment: maximizing the benefits of its four pillars Basic; Construction, Systems, User Services, Management [2]

3. Characteristics of smart buildings.

The smart building provides efficient productivity, cost effectiveness, internal and natural environment, optimum utilization of structural, management systems and coordination of interrelationships between them, and helps to achieve this set of characteristics: [3]
1. Automatic control.
2. Achieve the appropriate response to the needs of occupants of the building.
3. Adaptation based on changing environmental performance and the needs of occupants of the building [4].

4. Previous studies.

The paper in this paragraph reviews a series of previous studies dealing with smart interfaces and the design of openings in them:

4.1. Study Bugarin and Others, 2014

The study discusses a range of technologies that have been used in the construction of smart buildings, which contributed to the reduction in the amount of energy consumed by designing energy efficient glass enclosures[5].

4.2. Study konbr, 2016

The study considered that smart systems that can be used in smart buildings are an important entrance to achieve sustainability as they are of environmental and economic importance and achieve environmental balance and provide comfort for the occupants of the building. The study presented several examples of different systems used in buildings[6].

4.3. Study Omar, 2018

The study dealt with intelligent building systems in which the building and its parts can be made intelligent. Factors related to the design of such systems are eight components of the quality condition. The main factors besides energy, environment and space factors are flexibility, cost effectiveness, customer comfort, work efficiency, safety, culture and technology[7].

Most of the previous studies examined in intelligent building systems did not examine the design of openings in the smart faced of buildings in detail and the absence of a clear theoretical framework addresses the design of smart openings for buildings.
5. **Classification of the techniques used for openings in contemporary facades.**

After studying a number of examples, we can classify a number of techniques used in the facades of contemporary buildings such as:

5.1. _Dynamic openings/ Facades._

"The building envelope acts like a skin, an intermediate between the interior and the exterior. This skin has evolved over time, with the help of the engineered solutions; the purpose of dynamic facades is to assist in the progress of Sustainable and Responsive architecture. The dynamic facades act as filters between the indoors and the outdoors, facilitating the users providing appropriate shade, sunlight, ventilation and a visual union with the world in motion outside.[11] It is not a new idea, but it is only recently that architects have started utilizing this technology in their structures and design. There are a number of types of dynamic facades that we can classify depending on the mechanism of operation and operation and as follows:

5.1.1. _User manual control._

In this type, the dynamic building Facades of the building user will be moved manually, where there are no control sensors or the like. It is a simple system, usually a board and a sun louver that allows the user to control the sun louver and control the amount of natural light entering the interior of the building space. One example of this system is the Kiefer Technic Showroom in Austria (2007) by Gieselbrecht & Partner figure (2).

5.1.2. _Light projection by sensors._

In this type, the original facade structure is usually covered with two layers of metal sheets, which are often made of aluminum. The first outer layer of many louvers separates spaces. These louvers are fixed and straight. The second layer is louvers with movable angles. Sensors for natural and artificial lighting so that their color changes at any time between the night and the day. It also contains artificial light (Variable colors) sensors so that the final product of the person looking at that facade is a multi-wave dance interface. This type of façade is used for aesthetic and special purposes to give illusion. sight For my view of the building, the most prominent example of this type is Multi-use center in Korea by UN-Studio 2010 figure(3).
5.1.3. **Light control**

This type integrates the two previous types, although it depends mainly on computer-related sensors, but we can control it manually. This type of lens is similar to the camera lens connected to sensors that control the amount of light input into the space, this type is also a model of environmental control of the building, it also offers a variety gives the building aesthetic of its own, one of the most important examples of this type is Institute du Monde Araba in France, Paris by Jean Nouvel 1987, In this example, we note that the designer borrowed the traditional Arabic decorations and converted them into a number of lenses associated with sensors connected to a group of computers that control the amount of lighting entering the southern facade, adding to the building an aesthetic value as well as an environmental treatment figure(4).

5.1.4. **Shading system of PTFE clad.**

It is one of the most modern systems in the packaging of facades. It consists of a layer of PTFE clad, which is connected to a number of temperature sensitive electronic sensors in addition to the amount of carbon emitted from the building outside, which reduces the emission rate of carbon by 40%, was used in many ways Contemporary Towers of the Arabian Gulf Buildings Due to the very sunny weather and high temperatures in this region, one of the most prominent examples of this type is Al Bahar Towers in Abu Dhabi 2011, Where Almstsmom inspired the idea of marshmallows in this
building so that the building became more like skin is based on a structure like as Arab Mashrabiya figure(5).

Figure 5. Al Bahar Towers in Abu Dhabi (2011)

5.1.5 Wind sensor system.

The four previous types deal mainly with lighting. In this type, the façade deals with the wind as one of the natural forces that we can invest as a kind of renewable energies. In this type, the facade will be the openings will be small pieces square or rectangular or any shape and a large number to move dynamically with the movement of air in any direction was, these pieces at the same time are sensors that convert this kinetic energy to clean electrical energy used by the building in the process of cheating The most prominent example of this type is Brisbane Terminal Car-park in Australia 2011, The facade of the building consists of 250,000 small square pieces made of aluminum that respond to the movement of the wind. The front of the building is like a piece of wavy moving cloth, giving the integrated (wind) nature between the inside and the outside figure(6).

Figure 6. Brisbane Terminal Car-park in Australia (2011)

5.2. nanotechnologies openings/ Facades.

The term “nanotechnology” is often used as an all-encompassing term for science, engineering, and technology conducted at the Nano scale level- which involves the understanding and control of matter at dimensions between approximately 1 to 100 nanometers (nm). For reference, a single nanometer is one of millionth of millimeter. It would take roughly 50,000 nanometers to span the diameter of an average human hair.[8]

Nanotechnology has been used in many industrial applications, which in turn have led to the construction of buildings. Many nanomaterials have appeared in the installation of buildings such as self-draining glass. There are also nanomaterials that take heat energy from the sun to convert it into electrical energy. Clean The building is provided with the necessary energy used by its occupants. All of these materials can be referred to as smart materials (nanoparticles(. We will discuss in this
paragraph a number of techniques that are included in the installation of openings for the facades of contemporary buildings:

5.2.1 *Geotube system nanotechnology.*

This system is one of the most prominent applications on nanotechnology, which is a transparent rod structure works around the structure of the building to produce a distinctive form of the building's openings, and is made of several layers of nanomaterials, these bars are supplied with saltwater, Of salt-resistant (FRP) nanoparticles (FRP). When salt water passes cold, the salt is deposited on the inner layer. It is negatively ionized by its interaction with the sun that passes through the outer layer containing PV cells and passes inward It aims to give fresh air medicine Inside the building, because the negative air, according to studies, is found in nature when waterfalls and fresh water, which gives the natural air and natural caves, in addition to the introduction of a third layer of PV cells, which provide the building energy through the interaction of sunlight with salt Lying on the inner layer(figure 7)[9].

![Image of Geotube system](image)

**Figure 7.** third layer of PV cells

The (GEOTUBE TOWER) by Faulders Studio in Dubai is one of the most prominent examples of this system. The system is used because of the availability of salty Gulf water. This system distinguishes the warm, undesirable air from cool, cool air (figure 8)[10].

![Image of different layers of the Geotube system](image)

**Figure 8.** shows the different layers of the structure of Geotube system

5.2.2 *Nano_Ven_Skin (N.V.S) system nanotechnology.*

The system is a skin-like plate containing nanostructures that capture sunlight and a nanometer-sized turbine to catch wind. This combined energy is converted into nanomaterials linked to nanowires that transport electrical energy from This interaction to the collective units lies at the end of each plate of these nanoparticles. This nanotube also contains a filter that purifies the air of carbon dioxide so that the air enters purely into the architectural space. Another advantage of this system is the ability to repair itself. If one of the solar cells or one of the solar wind turbines is disrupted, the nanowires will send a signal to the central computer, in turn, to give the matter to the nanomaterials to fix the problem through this wire (figure 9)[11].

![Image of Nano_Ven_Skin system](image)
Figure 9. Shows the composition of the skin used in (N.V.S) system nanotechnology

One of the design companies named (NOS) from Mexico 2008 introduced this system into one of the designs proposed by it. The designer benefited from the beachfront project site (figure 10).

Figure 10. Tower proposed by (NOS) in Mexico (2008)

5.2.3 Fiber optic rods system nanotechnology.

In this technique, the system consists of a series of long bars, ranging from 3 to 7 meters long and 1-2 meters wide, containing a set of optical fiber nanocompositions, containing the ends of the sensors on the receptor of the light, from outside, these bars are through Sensors at the edges to take the sun and then converted by optical fiber nanoparticles inside to illuminate the interior spaces, at night, the sensors that are located on the inner sides of the space will receive the industrial light of the interior architectural space and transported by the same process of output, but into outer space Which makes the block of the building glow, where the process meets the process of external lighting beautiful night. This technique is usually used in exhibitions, which require an external aesthetic architectural form and the need of interior spaces for natural daylight and industrial outdoor lighting at night. This fiber and along the path of the rods provide photovoltaic sensors that transfer this energy through nanowires to the cooling systems and internal air conditioning of space. The most prominent example of this system is Shanghai world expo UK pavilion by Thomas Heatherwick (2010) Where the designer designed this system to meet the needs of the exhibition pavilion of the United Kingdom, using the system of seed cathedrals. In addition, the system in each rod placed a colorful plant seed where light passes through the optical fiber nanoparticles, penetrating the seed and analyzing the colors, which gives a visual diversity of colors a lot (figure 11)[12].
5.2.4. Anti (dust_water) system nanotechnology.

This technique is usually used in towers where it is difficult to access buildings to clean the building openings of dust and plankton, and they are even used in airport control towers where rainwater can obstruct the visibility of these openings. The windows of these openings are usually coated with nanomaterials, for example titanium oxide (TiO2), where they interact with water and dust plankton to react together to form a layer that avoids glass that separates it from it (figure 12)[13].

Figure 12. Shows the work of anti (dust_water) system nanotechnology

One of the most prominent examples of this is the proposed airport near the sustainable city of Masdar in Abu Dhabi by Kyosemi Corporation where the sand winds in the region blowing throughout the year, which leads to the difficulty of cleaning the glass in addition to the cost of high-altitude, which led the designer to choose this technology in the openings of the proposed airport, The flight control tower and the proposed roof lighting for the airport space figure (13)[14].

Figure 13. airport road near Masdar in Abu Dhabi(2006)
5.2.5. diode (LED) nanopix system nanotechnology

It is a technique based on nano-sized light units spaced 1 μm in background on a reflective coating coated with nano-chemical, which seeks to reduce the area and focus of light produced compared to conventional addition techniques [15].

This technique is used in the facades of buildings and their openings, in order to achieve the aesthetics and the low maintenance costs compared to conventional systems. This technology can be combined with sensors of photoelectric cells so that they light the light of the day and store it and convert it into sustainable electric energy These nanoparticles are one of the most prominent examples of this system being the GreenPix: Zero Energy Media Wall in the Chinese capital of Beijing (2008). The color wall of this technique is like interactive skin. The wall contains photovoltaic cells that store light Confidential and stored to run the screen at night figure(14)[16]

![Figure14. GreenPix: Zero Energy Media Wall in Beijing (2008)](image)

6. Theoretical framework.

After classifying the contemporary techniques of smart openings for contemporary buildings and viewing many examples, we can build a theoretical framework described and explain what these openings in terms of the technology used for its work and implementation, as in Table (1):
Table 1. Smart Openings For Contemporary Buildings

| Working Mechanism | Type of technical work | Made materials or compound-made for the purpose of work | techniques used for openings in contemporary facades |
|-------------------|------------------------|----------------------------------------------------|---------------------------------------------------|
| physicist         | dynamic                | Engine louver                                      | User manual control                               |
|                    |                        | Aluminum sheets                                    | Light projection by sensors                        |
|                    |                        | Engine sensor                                      | lens-Light control                                 |
|                    | static                 | Steel louvers fixed                                | Wind sensor system                                 |
|                    |                        | Light projection by sensors                         |                                                   |
| Air reaction       | Salt-resistant (FRP) nanoparticles |                                                   | Geotube system nanotechnology                      |
| Chemical           | Nanotube filter air of carbon dioxide | Nano_ Ven_Skin (N.V.S) system nanotechnology |                                                   |
|                    | Skin-nanostructures    | Nano_ Ven_Skin (N.V.S) system nanotechnology       |                                                   |
|                    | Nanomaterials(titanium oxide (TiO2)) | Anti (dust_water) system nanotechnology  |                                                   |
|                    | Electrical reaction    | Nano-sized light                                   | Diode (LED) nanopix system nanotechnology         |
|                    | Optical fiber nano compositions+ sensor Electrical | Fiber optic rods system nanotechnology; contraction |                                                   |
|                    | Interaction between chemicals | Solar wind turbines nano structure | Nano_ Ven_Skin (N.V.S) system nanotechnology |                                                   |
| Hybrid (chemical + physical) | Nano-sized light units + reflective coated with nano-chemical | Diode (LED) nanopix system nanotechnology |                                                   |
|                    | Electrochemical reaction | Optical fiber nano compositions+ | |                                                   |
|                    |                        | sensor Electrical | |                                                   |
|                    | Aerobic reaction       | Chemical sensors                                   | Light projection by sensors                        |
|                    |                        | PTFE clad+ electronic sensors                      | shading system of PTFE clad                         |

7. Conclusion.

1. The use of modern techniques in the design of contemporary buildings and their various parts, including openings, plays a major role in improving the performance of the building and providing a more interactive and appropriate environment for the occupants of the building, which is one of the important aspects of 21st century architecture.

2. Smart openings for contemporary architectural buildings are those that include one of the smart technologies, whether the physical composition and manufacture, such as dynamic sensors or chemical synthesis and manufacture, such as nanotechnologies.

3. After classifying a number of intelligent technologies for these openings and constructing their theoretical framework, we noticed that most modern intelligent technologies are usually associated with smart materials such as water-based materials such as nanomaterials.

4. The good design of the openings can contribute effectively to increase environmental efficiency, reduce energy consumption, assist designers in the process of architectural design and achieve an aesthetic addition to the facades of their buildings.

5. Through the theoretical framework we observe the technique Nano_ Ven_Skin (N.V.S) system nanotechnology is one of the most classified technologies that fall within the chemical work and agitation that combines chemical and electrical.
8. References

[1] S Kjeld 2002 Intelligent Buildings – a short overview. Alborg University. P . 3.

[2] Seattle Conference. 2001. Building Smart, Building Green. Intelligent Buildings Institute (IBI). P3

[3] M Addington & D Schodeck. 2004 Smart Materials and Technologies for the architecture and design professions, Architecture Press, an imprint of Elsevier , Linacre House, Jordan Hill, , UK..

[4] I Abiodun,W Wanggen and Chi Z 2011. Energy Management for Intelligent Buildings, Energy Management Systems, Dr Giridhar Kini (Ed.).

[5] M Bugarin,S Nizetic and Z Domazet.2014. Intelligent Glazed Facades Nearly Zero-Energy Buildings, ttps://www.researchgate.net/publication/305477500.

[6] U konbr , 2016, Smart Buildings and Sustainability in Egypt - Developing a Concept and Developing a Curriculum. Journal of engineering sciences 44(4):PP. 472 – 501

[7] O Omar ,2018, Intelligent building, definitions, factors and evaluation criteria of selection. Alexandria Engineering Journal (2018) 57, 2903–2910.

[8] I Yasin and D Atiyat, 2017, The Effect of Nano Technology on Architecture, Int'l Journal of Advances in Agricultural & Environmental Engg. (IJAAEE) Vol. 4, Issue 1 (2017) ISSN 2349-1523 EISSN 2349-1531.

[9] https://www.faulders-studio.com/

[10] https://www.designboom.com/

[11] P Premier, 2012, Dynamic Facades And Smart Technologies For Building Envelope Requalification. ttps://www.researchgate.net/publication/269690115.

[12] https://www.archdaily.com/58591/uk-pavilion-for-shanghai-world-expo-2010-heatherwick-stud

[13] https://www.teknik.uu.se/solid-state-physics+/materials+for+energy-efficiency-and-environmental-applications/#anchor-62983

[14] www.landartgenerator.org

[15] https://www.researchgate.net/publication/224119867_Enhancement_of_light_extraction_in_ultraviolet_light-emitting_diodes_using_nanopixel_contact_design_with_Al_reflector

[16] https://www.archdaily.com/245/greenpix-zero-energy-media-wal