Interactive and smart facades technology and its environmental impact

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Introduction

Building technology development processes are products and materials for architectural facades; A continuous process, as construction technologies have evolved and depend on modern machines, followed by interactive and smart facade technology.

Architectural facades are of importance in the building, hence the role of researching the technology of interactive and smart facades and presenting illustrative models through which the idea and interaction technology of these facades are illustrated and determine their environmental impact.

Smart and interactive facades are distinguished not only in terms of appearance; Rather, it can control the building in terms of temperature, save energy, give the required protection and safety, and it can even affect the surrounding environment.

Interactive and smart façades also include the technology of cladding façades from materials and techniques, through the application of advanced technology and industrially and environmentally advanced building materials that are interactive in nature and are distinguished by industrial and environmental specifications.

From the research study, the environmental impact of interactive and smart facades can be determined, and the compatibility of interactive and smart facades with environmental sustainability systems.

Research problem:

The research focuses on answering four main questions that are considered the focus of the research, and they are:

-What is the interaction technology in the interactive and smart facades؟

-Is the technology of interactive façade cladding linked with environmental systems through the application of advanced technology and building materials developed industrially and environmentally؟

-What is the environmental impact of interactive and smart facades؟

-Is the interactive and smart facade technology compatible with sustainable environmental systems؟

DOI: 10.21608/MJAF.2021.69005.2293

Research aims:

-Knowing the types of interactive and smart facades technology.

- Interactive and smart coating technology specifications in terms of technologies, materials and their environmental impact.

- Determine the environmental impact of the interactive and smart facades.

Research hypothesis: The research assumes that interactive and smart facade technology is compatible with sustainable environmental systems.

Research Methodology:

The research follows the descriptive-analytical approach: describing and analyzing models of interactive facades.

It also follows the experimental analytical approach: This includes designing a questionnaire, and analyzing it to confirm the research hypothesis.

Search limits:

Temporal Frontiers: Mid-Nineteenth Century, Present and Future Period.

Spatial boundaries: It includes Arab and European cities in which the interactive and smart facade technology has been applied.

Research Procedures: Preparing a questionnaire to evaluate the results of the research, consisting of (5) paragraphs, to find out the opinions of specialists from the faculty members of the Department of Interior Design and Furniture and the Department of Decoration and the Glass Department of the Faculties of Applied Arts, Helwan University, Damietta University, Benha University, 6th of October University, and the Higher Institute of Applied Arts in the Fifth Settlement and the sixth of October city.

Research sample: (30)specialists in interior design, furniture, decoration and glass.

Search terms: interactive and smart facades, facade cladding technology, ecosystem, environmental impact, anchoring structure.

Facade technology has achieved many developments in both building materials and technology, building facades have been freed from being fixed to facades that interact with residents and the environment, and nanotechnology has also entered the production of materials and technology for facade claddings such as: metal panels, insulation materials, paints, and glass, with the aim of improving their industrial and environmental properties in terms of weight and durability, ease of maintenance, fixed color, weather resistance, and other advantages. Many terms have also been associated to express technologically advanced architecture in general, including:

Technological architecture, sustainable architecture (green architecture), smart architecture, interactive architecture, interactive and smart facades.

The facades protect the building from external factors and contribute to creating a comfortable internal environment, and is mainly responsible for thermal gain and loss, so it is the part that carries technology capable of making the building adaptable to the environmental

conditions of the place in which it is located, interacts with it, affects and be affected by it which is called the environmental impact.

Environmental impact: The impacts resulting from projects, including materials, construction technology and production, which affect human health, nature, the beauty of cities, and cultural heritage.

The environmental impact aims to reduce environmental pollution, achieve a balance between the environment and development, and preserve the components of biological diversity.

Interactive and intelligent facades are equipped with dynamic or programmatic technologies in part or in the entirety of the facade.

Architectural facade includes:

Architectural openings.

Cladding materials

Supplements and decorative accessories.

(A) "Ventilated facades":

It is a multi-layered façade and relies on an anchor structure to install various cladding materials such as chipboard, Aluminum, glass, ...). Germany has been the birthplace of ventilated facade systems since the 1950s. Ventilated facades are characterized by reducing the amount of building materials needed to construct building walls, thus saving costs during construction, and the possibility of reducing or preserving the heat inside the building, while preventing the emergence of moisture, thus raising building efficiency. The ventilated facades have multiple industrial and environmental specifications **Figure (1)**.

Figure (1) a section showing the layers of the ventilated facade

(B) Models of interactive facades and their environmental impact:

First model: Mechanical dynamic interaction (Facade Kiefer Technique Gallery) Austria.

Interactive idea: The appearance of the facade changes at times of day with changing the position of the external screens in the facade, opening and closing according to the strength of the sun's rays. Contributes to saving energy consumption, and the stainless aluminum works to achieve durability, good appearance, fire resistance and longevity.

The second model: An illusion dynamic interaction (facade of the floor-parking building, Sknazi Hospital), Indianapolis, United States of America.

Shape and colors of the façade change, depending on the angle and location of the viewer on the façade.

The façade provides shade and protection from strong sunlight during the day which reduces energy consumption, and becomes in harmony with the environment.

The third model: mechanical dynamic interaction (Abraj Al Bahar facade) Abu Dhabi, UAE.

The façade is programmed to move dynamically when exposed to sunlight through units that open and close daily. Taking inspiration from the "mashrabiya", which provides shade and privacy, reduces sunlight and reduces energy consumption **Figure (2).**

Figure (2) The units on the facade interact by opening and closing according to the strength of the sun's rays.

Fourth model: manual dynamic interaction (building façade (Checker Box Office) complex) Tehran - Iran.

The facade is moved by the user, using wooden strips moving over the fixing frame. It works to provide shade and save the building's electrical energy consumption, in harmony with the building and the environmental surroundings.

The fifth model: a dynamic interaction between Syddansk Universitet in southern Denmark.

The facade moves dynamically in a software system, through modules that open and close.
The units open fully or separately, providing thermal comfort and reducing energy consumption.

Sixth model: GreenPix - Zero Energy Media Wall Building Sustainable Digital Media Wall, Beijing, China.

The Facade is a curtain wall that applies digital media technology to the entire facade of the building. It is a light (LED) display screen with photoelectric technology to store the natural energy of the sun. Achieving self-sufficiency in energy and rationalizing the consumption of electric energy.

External cladding materials of a reactive nature:

Firstly, Aluminum cladding panels: (Alucopond) thickness of 4 mm, two aluminum strips of 1mm thickness coated with PVDF material, acting as insulation, it is weather resistance، non-combustible.

Second, smart interactive paints:

Paints are commonly used for protection and beautification, it is smart and interactive when it has the capabilities of sensing and detection. Several types of paints appeared that can detect chemical substances, note vibration, are environmentally friendly, and have good environmental characteristics

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Ceramic Insulating Paint (ANZ): Advanced reactive paints consisting of a coating material that acts as an insulating cover, reflecting heat and saving energy.

Third, reactive glass types with facades:

Types of façade glasses of a reactive nature with external stimuli.

١. **Glass that changes color when there is a catalyst (reactive glass):** a transparent façade Glass that allows natural light to enter and gain solar heat. **Figures (٣ & 4 & ٥).**

Figures (٣ & 4 & ٥) interactive glass that transforms from a clear, non-tinted glass to a tinted transparent glass with control to

٢. **Smart glass:** The glass turns from an opaque state and impermeable to light to a transparent state, or semi-transparent according to the user's need .

٣. **Self-cleaning glass:** This type of glass reduces the need for continuous cleaning, thus rationalizing water consumption and reducing the use of environmentally harmful detergents. That is, the glass is cleaned by rain or just by spraying water on it.

٤. **Glass with solar energy condensers:** the windows and facades of buildings are converted into an energy storage surface and are used to generate natural energy that is not harmful to the environment. It can also be cleaned and maintained.

Figure (6) Part of the building's facade cladding from plastic wood with the

Fourth (smart) wood plastic WPC:

Plastic wood is manufactured through a number of technologically advanced manufacturing stages. Which can convert it to the desired cladding product **Figure (6).**

Fifthly, luminous transparent concrete:

Cement, optical fiber and soft breaking concrete that transmits light from natural or industrial sources. It is used in creative architectural works, building façades, and interior walls.

Environmental impact criteria for interactive and smart facades:

1 .Applying technology that does not pollute the environment or damaging the ecosystem.

2 .Using environmentally friendly cladding materials that do not emit odors or gases to the environment.

3 .Weather resistance, as harmful UV rays, dampness, rain, frost.

4 .Fire resistance. The ideal material for cladding is non-flammable and does not release toxins during combustion.

5 .Bio-stability & resistance for mold, fungi and insects.

6 .Providing protection for the building through durability and insulation strength.

7 .In harmony with the environment in color, shape, or cultural heritage.

8 .Longevity, modern cladding materials have a service life of 20-100 years.

9 .Ease of maintenance, and it has the ability to clean itself.

10 .Energy self-sufficiency, or the rationalization of non-renewable electricity consumption.

11 .Take advantage of renewable natural energy sources.

12. Preserving natural resources.

When these standards are met, interactive and smart building façades are compatible with sustainable Ecosystem.

A questionnaire was designed to measure the research hypothesis and verify the results by a group of specialists of (30) faculty members from the departments of interior design, furniture, decoration and glass.

From the Faculties of Applied Arts: Helwan University, Damietta University, 6th of October University, Benha University, and Beni Suef University.

Results

١. Interactive buildings have succeeded in creating a responsive environment by achieving integration between technological systems and ecosystems.

٢. Some interactive interfaces have a positive environmental impact in preserving the environment, and using advanced technology without causing damage to the ecosystem.

٣. Interactive and smart interfaces can become sustainable when they contribute to reducing energy consumption, making use of renewable energy, and preserving natural resources.

٤. The advanced facade technology can control the building temperature, save energy, and provide protection for the building by applying "ventilated facades" technology.

٥. Reactive coating materials and products of an interactive nature, such as alucopond panels, types of interactive and smart glass, interactive and smart paints, and plastic wood.

٦. Reactive coating materials and products were distinguished by unique industrial and environmental specifications, the most important of which are (resistance to all weather factors, fire resistance, resistance to mold growth, durability, longevity, ease of maintenance).

٧. Interactive and smart interfaces are compatible with environmental sustainability systems when they meet environmental impact standards.

Recommendations

١. Increasing the number of researches in the field of developing traditional cladding materials and products and their technologies.

٢. Developing the “Facade Cladding Technology” course by adding interactive and smart facades technology.

٣. Determine the standards of building compatibility with the environment.

٤. Adherence to local and international environmental standards.

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