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INTELLIGENT FACADES AND THEIR ASSOCIATION WITH BIOMIMICRY ARCHITECTURE: HOW TO IMPROVE AIR QUALITY BY USING SMART BUILDING SKINS?

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ABSTRACT

Technology in architecture—from computational design to apps—has architects doing more than designing and supervising the construction of buildings. Today's architects have to solve the mistakes of the past by adapting the buildings to the environment. Biomimetic architecture is a contemporary philosophy of architecture that seeks solutions for sustainability in nature, not by replicating the natural forms, but by understanding the rules governing those forms. However, how can we apply this type of architecture to building skins? Intelligent facades are leading the way in the design and supply of building facades for the architectural and construction industry. Buildings play a key role in organization and arrangement of city appearance. Specially, their facades have profound impact on the quality of urban landscapes while playing an important role in assessing urban environments by citizens. Poor air and water quality, and high energy consumption are exacerbated by the increasing population density and demands of urban environments. Here, the role of archites is of great importance.

Keywords: intelligent facade, biomimicry architecture, smart building skins, sustainable architecture, Tirana smart facades

1. INTRODUCTION

In the present paper, facades are studied for a better understanding of biomimicry architecture and the role it plays in modelling and designing of intelligent building.

Facades are usually the exterior of a building. The facades of a building are aesthetically important. Facades represent the architectural language for the whole building as they are a combination of walls, doors and windows which in their entirety create, give shape and character to a building.

The facade is the main constructive element of a building to meet the requirements of energy efficiency and interior comfort.

The present study aims to achieve a combination of intelligent facade architecture with biomimicry architecture, through imitating nature and giving the building elements that are not only aesthetically appealing to the naked eye, but also valuable in terms of energy efficiency, thus positively affecting the environment.

The present and future architecture, must bring architects face to face with nature through new designs in order to be as close as possible to it by finding solutions that not only positively affect the future but also improve the situation we currently have now (Adams 1997) .

In recent years building facades have become increasingly significant due to unconventional choices of materials and the use of innovative technology. More and more, the external surfaces are being perceived and designed as an integral part of the building. This skin, a protective mantle, defines not only the interior but also the adjoining exterior space. It is its visiting card of the building. Visionary architecture refers to architecture that meets both engineering and environmental demands. In addition, it requires the discovery of new forms and content, and the assertion that the art of construction is in a new phase which will definitely change our way of living, always in accordance with the language of nature(Alexander 1987). The present study exemplifies the way the new forms of architectural design imitating nature completely change the old fashioned way of building design, especially intelligent facade which helps the architects to meet environmental demands.

2. METHODOLOGY

The present paper investigates the role biomimicry architecture plays in sustainable architecture and structure design, by focusing on building improvement and applying the basic principles and rules of bio architecture, for projects and designs that are as environmentally friendly as possible.

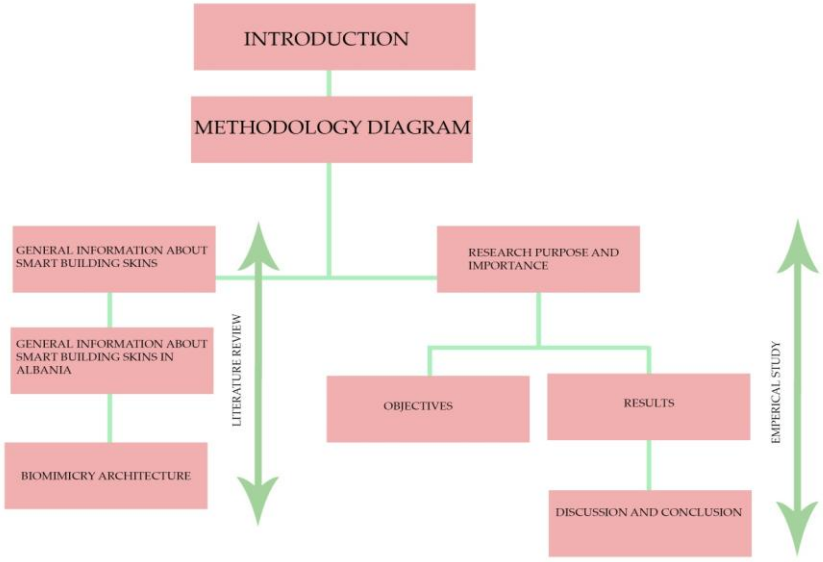

Fig. 1: Methodology diagram.

This research proposal (Fig.1) addresses a range of complex architectural issues and the definition of intelligent building skins and its role in the construction environment. This lack of clarity within the subject may challenge how facades can be translated into a crowded city and environment (Baird 2001). Once the way this technology works is studied and understood, determing its incorporation and application area would be important. Hence, this research does not only reviews the literature and explains how the technology and system work, but also clarifies how we can use it in existing buildings. In the end we will prove whether it changes the air quality or not.

General information about smart building skins

The architecture of the facades at the beginning of the twentieth century show a traditional and mostly static design. The architecture of the 21st century is more dynamic and technologically advanced. In addition, it has become adaptable to the environment around us. It incorporates natural light, energy efficiency and technical comfort (Luis 2007).

If a facade is complex and interesting, it has a positive effect on people, and it is a helpful to the urban development. It should be adapted also keeping in mind the surrounding byildings and not only the shapes and materials that were used to crete it (Ine 2004).

However, all these features are strongly related to the great success that the translucent and transparent surfaces have in the era of contemporary architecture. Within this context, other elements such as mobile sun protection devices (shutters and external shaders) which are incorporated into the building, also play a very important role. Traditional or innovative materials can be used for these devices. The difference between traditional and innovative materials is quite complex, but the natural materials are preferable because they do not cause chemical damage to the soil in case of a natural disaster. Here we can mention wood and ceramics as well as very complex materials which give the facade thermal stability.

Example of smart skin facade in the world:

Energy-producing algae facades

The figure 2 depict a wall of 2,150 m^2, which was implemented and tested for the first time in Germany in 2013. It is the result of three years of testing by a group of designers (Splitterwerk Architects and Arup).

Its rather vibrant colors are more appealing aesthetically appealing. The wall has been painted by millions of microscopic algae plants, which is fed with nutrients and oxygen for biomass production.

Fig. 2: Energy producing algae facade (further information could be found in http://www.morethangreen.es/en/solarleaf-solar-leaf-algae-bio-reactive-facade/).

There is a direct trajectory of the sun's rays from which the rapidly growing small cells end up heating the water. The heat is collected by the system and stored for use in the building (Fig. 3).

Fig. 3 Energy producing algae facade(futher information could be found in http://www.morethangreen.es/en/solarleaf-solar-leaf-algae-bio-reactive-facade/ **)**

A facade that eats smog

In 2011, Alcoa, accompany involved in the chemical industry reported about an extraordinary technology that could purify and filter the air. The material contained titanium dioxide, which effectively filtered air to remove toxins released by cars and factories, thus releasing spongy free radicals which can eliminate air pollution (Fig. 4) (https://architizer.com/blog/inspiration/industry/smog-eating-facades-and-the-future-of-our-air quality/#:~:text=The%20innovative%20technique%20has%20recently,TiO2%20developed%20by%20Elegant%20Embellishments.

Fig.4: Facade that eats smog, Hospital at New Mexico City (further information could be found in https://architizer.com/blog/inspiration/industry/smog-eating-facades-and-the-future-of-our-air-quality/#:~:text=The%20innovative%20technique%20has%20recently,TiO2%20developed%20by%20Elegant%20Embellishments)

This technology has been applied in different areas such as fashion design and civil engineering. Here we can mention the Torre de Especialidades, the hospital building in New Mexico City (Fig. 5).

Fig. 5: Facade that eats smog, Hospital in New Mexico City https://architizer.com/blog/inspiration/industry/smog-eating-facades-and-the-future-of-our-air-quality/#:~:text=The%20innovative%20technique%20has%20recently,TiO2%20developed%20by%20Elegant%20Embellishments

Smart building skins in Albania

In the early 1990s, little attention was paid to the quality of facades in Albania. Constructors and architects were focused on the market demands about the design of residential buildings (Christian 2006). So, the desing style of the facades is very poor and the materials used were simple plastering, paints of low quality.

Although, construction industry has marked a significant increase in construction quality due to the use of innovative technologies construction materials, Albanian architecture remains far from being distinguished from the other countries. However, there are quite intriguing projects.

Thermal facades

Figure 6 depicts an example of thermal facades in the Ali Demi area, in Tirana. The project started in 2018 and is being implemented by a foreign studio in close collaboration with an Albanian company. The buildings has a residential and service function and a maximum of 9-stores The ground floor is focused on all services such as shops and warehouses.

Fig. 6 Buildings with thermal facade in Tirana.

Rock wool was used for the facades, because it more resistant than traditional insulation and provides a better protection against fire. The fibers of rock wool can withstand more than 1000° C without melting. This characteristic makes this material a leader in energy consumption which is of great benefit for the residents. In addition, it provides excellent sound absorption. Stone wool has a porous and open structure, which absorbs sound like nothing else.

Ventilated Facade

Figure 7 depicts an 8-storey building for residential and service purposes with ventilated facade. The construction finished in 2017.

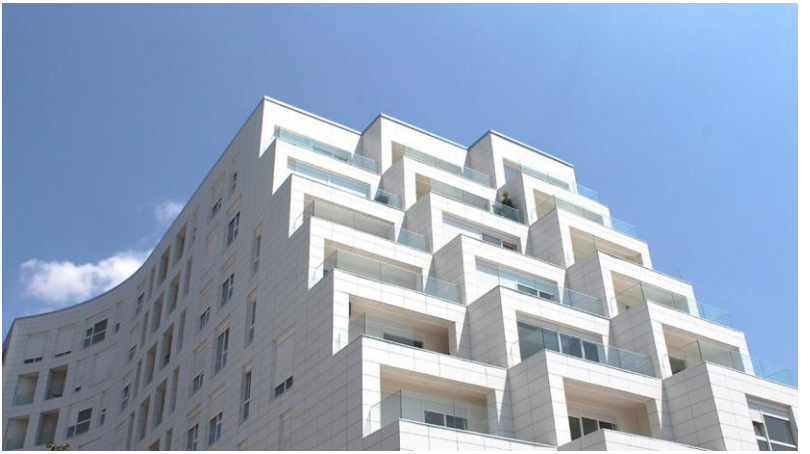

Fig. 7: Building with ventilated facade in Tirana.

Ventilated facades enable the use of a wide range of elements for its exterior cladding, both in terms of materials, shape, and dimensions.

Another characteristic of the typical ventilated facade cladding is the placement of a material in the dry state, which is an unusual construction technique (Bengs 1993) . We usually use cough and other adhesive materials, but the opposite happens when using water to wet it. The thermal properties of this system are based on the basic principle of the "chimney effect", obtained by leaving an air gap several centimetres deep between the perimeter wall of the building (covered with a layer of insulation) and the outer face. Ventilated walls are a layer of protection with high thermal inertia in both seasons: in summer, they offset the heat (i.e. less heat enters the building by conduction and only at night, as the temperature is lower) and in winter they extend the time it takes for the perimeter wall to cool down (Fig. 8).

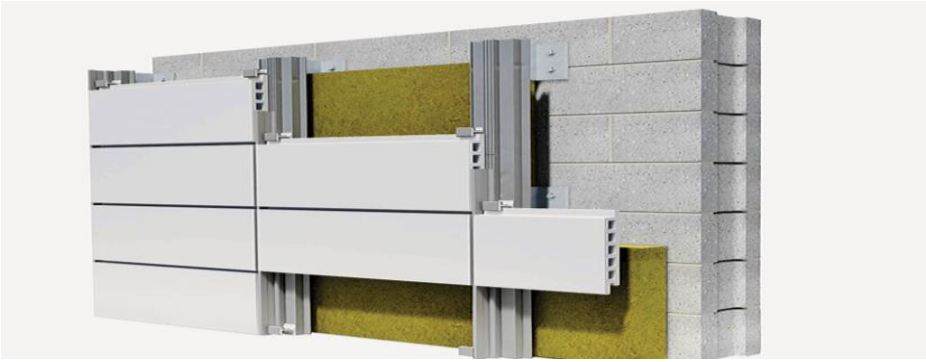

Fig. 2: Ventilated facade details.

Insulation is of great importance as it guarantees external impermeability and does not create barriers to the steam coming from inside.

Biomimicry architecture

The biomimicry architecture plays a great role in the modelling and designing of eco-friendly buildings.

As science and technology feed off of one another, propelling both forward, the use of smart and sustainable facades became unavoidable. The new ways of generating energy have influenced the design of building skin. The concept of the shrewd exterior has just been around for a couple of brief decades, supported by the late advances in the concoction and material science. Furthermore, in the course of recent years, we have seen the classification blast (Michael 2011).

Underneath, look at probably the most intriguing structure veneers to run over the screen as of late: from a warm metal screen that twists up when it is hot, to a titanium dioxide-secured divider that diminishes contaminations.

In 2011, was declared the production of an innovative solution to the air purification which consisted of titanium dioxide, which adequately "scoured" the demeanour of poisons by discharging supple free radicals that could dispose of toxins(https://architizer.com/blog/inspiration/industry/smog-eating-facades-and-the-future-of-our-air-quality/#:~:text=The%20innovative%20technique%20has%20recently,TiO2%20developed%20by%20Elegant%20Embellishments).

In addition to construction industry, this material has is also used in the textile industry for the production of different attires. Regarding the construction industry, it was used on the sunscreen of a New Mexico City clinic, the Torre de Especialidades.

The medical clinic is shrouded in a 300-foot-long skin of Prosolve370e tiles, created by the Elegant Embellishments, a German company. The innovation consists of air channels around the wipe formed structures, UV-light-initiated free radicals decimating current poisons, leaving the air cleaner for the patients inside. The Fast Company declared that even the state of the sunscreen is enormous (fig.4). It makes disturbance and hinders wind current around the structure, while dissipating the UV light expected to actuate the compound's response.

Purpose and importance

Usually, architecture's priority lies in the confort created through the design, interior spaces and the relationship with the urban development.

Architectural style has changed over the years by getting adapted to a world of increasing scientifi c and technical complexity, market demands and cost-effectiveness.

Biomimicry is one of the many tools to develop sustainable solutions for a balanced ecosystem by empowering people to learn and apply nature-inspired strategies in design. Cities are affected by smog because of traffic and overpopulation, so trying to approach new ways how to do better is an inspiring thing to behold for the future generations (Washburn. 2013). So, the primary objective of these technologies would be air purification. However, studies and investigations through literature review with regard need to be made to find appropriate solution for the environment, market demand and cost-effectiveness.

For the first time in the history of architecture, nature and social welfare and non-decorations, styles, luxuries or other superficial elements come first(Washburn. 2013), in addition to individuals' wellness (Ignacio 2010). At the same time, by intervening in the improvement of our social status, it also promotes a global improvement of nature.

3. RESULTS

The present paper aims to inform how this technology purifies the air. Consequently, it expemplifies through the Torre de Especialidades, a hospital building in New Mexico City. A material called Prosolve370e tiles produced by the Elegant Embellishments, a German company was used. Prosolve370e is a decorative architectural module that can effectively reduce air pollution in cities when installed near traffic ways or on building facades. Here, as air channels around the wipe formed structures, UV-light-initiated free radicals decimate any current poisons, leaving the air cleaner for the patients inside.

The Fast Company declared that even the state of the sunscreen is enormous. It makes disturbance and hinders wind current around the structure, while dissipating the UV light expected to actuate the compound's response. Here we cam mention the Manuel Gea González Hospital in Mexico City. The structure's proprietors have made the stride of including another "brown haze eating" facade covering more than 2,500 square meters.

The framework, planned and created by Elegant Embellishments, consists of thermoformed shells covered in photocatalytic titanium dioxide. This covering responds with light to kill components of air contamination, discrediting the impacts of up to 1,000 vehicles every day as per its engineers.

Prosolve370e is an extension element that is to be added to the building or an architectural module that can successfully reduce air pollution in different cities if installed near traffic ways or on building facades.

The modules are coated with a superfine titanium dioxide (TiO2), a pollution-fighting technology that is activated during the day by the natural daylights. Employing a distinctive design of this technology, the tiles defuse air pollutants when sited near traffic or heavily polluted circumstances.

The modules are a functional, yet highly attractive modular ornament that achieves synergy between design form and molecular technology. Inspired by fractals in nature and imitating the process of a tree by filtering the CO2, the undulating shapes maximize the surface area of active coating to diffuse light, air turbulence and pollution.

As a modification to existing architectural surfaces, prosolve370e essentially "tunes buildings" to respond better to their immediate environments (Arthur 2011).

It is a decorative module of few tooled parts and not non-repetitive pattern for facades that can effectively reduce pollution (NOx, VOCs, SO2). The modules are coated with superfine titanium dioxide (TiO2), a pollution-fighting technology that is activated by ambient daylight. Employing a unique configuration of this technology, the tiles neutralize air pollutants when sited near traffic or densely polluted conditions. The tiles are made of a lightweight thermoformed plastic panels. It is a standardized system for exterior and interior applications, a semi-customizable to project conditions, an innovative, eco friendly technology that could be used in the facades of the buildings, car parks, traffic tunnels / transport entrances and along motorways or urban circulars.

4. CONCLUSIONS

Given the current environmental conditions and the civil engineering situation, finding new eco-friendly and cost effective ways of constructing would be fundamental. The importance of the application of the new

technology lies in not only in the betterment of the environmental conditions, but also in betterment of the health conditions for the population. The smart building skins (Octavio 2011) is the future of architecture. Architecture is entering a new era of collaboration, in which successful new technologies, generated by large scientific projects across the world, will have a dramatic impact not only on environment but human health and society as well (Boulding 1978). These types of smart skins (William 1978) are already feasible and have a very positive effect on the environment. This new technology can be sited near traffic or heavily polluted circumstances.

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