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THE IMPORTANCE OF MODERN TECHNOLOGY FOR ACHIEVING THERMAL COMFORT IN ADMINISTRATIVE BUILDINGS

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ABSTRACT

Thermal comfort is considered a necessary requirement for users of various types of architectural spaces, serving as an indicator of the quality of the indoor environment. Therefore, this research focuses on the different images of technological advancements and their impact on the indoor environment of administrative buildings, specifically their thermal environment, due to its influence on the comfort of occupants. The research aims to understand the basic factors that affect the design of these buildings between the past and the present, in addition to clarifying the role of modern technology, including artificial intelligence and simulation programs. It also examines the use of modern technologies, materials, and different treatments in construction.The research adopts an analytical approach by analyzing the most important matters addressed in previous studies and research related to the subject in order to establish the relationship between modern technology and thermal comfort. Additionally, selected models of old and modern administrative buildings are analyzed to determine the extent of the impact of modern technological development on their thermal environment. By comparing the treatments and capabilities available in the past and present, the research concludes that modern technology, in all its forms, plays a major and influential role in the internal environment of buildings, particularly in terms of thermal conditions. The research proposes appropriate solutions to create a balanced thermal environment within the building.In conclusion, the research presents recommendations aimed at implementing and applying the findings in real-life scenarios, in order to benefit from the advancements achieved worldwide.

KEYWORDS: Modern technology, Thermal comfort, Administrative buildings, Quality of internal invironment, Environmental design

أهمية التكنولوجيا الحديثة لتحقيق الراحة الحرارية في المباني الإدارية

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الملخص

تعتبر الراحة الحرارية مطلباً ضرورياً لمستخدمي الفراغات المعمارية بمختلف أنواعها وهي مؤشر على جودة البيئة الداخلية، لذا تناول هذا البحث الصور المختلفه للتطور التكنولوجي واثره علي البيئه الداخليه للمباني الاداريه وتحديدا بيئتها الحراريه لما لها من اثر علي راحه الشاغلين مع محاولة فهم العوامل الأساسية المؤثرة في تصميمها بين الماضي والحاضر، بالإضافة إلى توضيح دور التكنولوجيا الحديثة بم فيها من ذكاء اصطناعي وبرامج محاكاة واستخدام التقنيات الحديثة والمواد والمعالجات المختلفه في البناء . اعتمد البحث على المنهج التحليلي من خلال تحليل أهم العناصر التي تناولتها الدراسات والأبحاث السابقة المتعلقة بموضوع البحث للتوصل إلى العلاقة بين التكنولوجيا الحديثة والراحة الحرارية، ومن ناحية أخرى تم اختياربعض النماذج من المباني الإدارية القديمة والحديثة وتحليلها لتحديد مدى تأثير التطور التكنولوجي الحديث على بيئتها الحرارية من خلال مقارنة المعالجات والإمكانيات المتوفرة قديما وحديثا، يتوصل البحث إلى الدور الرئيسي والمؤثر للتكنولوجيا الحديثة بمعظم أشكالها على البيئة الداخلية للمباني وتحديدا بيئتها الحرارية، بالإضافة إلى اقتراح بعض الحلول المناسبة التي تؤدي إلى إيجاد بيئة حرارية متوازنة للمبنى، كما تم تقديم بعض التوصيات بهدف تفعيل هذه الورقة وتنفيذها على أرض الواقع للاستفادة من التطور الذي حققه العالم.

الكلمات المفتاحية : التكنولوجيا الحديثه، الراحه الحراريه، المباني الإداريه، جودة البيئه الداخليه، التصميم البيئي .

1. INTRODUCTION

Administrative buildings are an important type of building classification due to their importance stemming from their size and the number of occupants, whether employees working in them or the public visiting these buildings. With the advancement of technology, administrative buildings have evolved, leading to the development of technologies and processes used in their design and construction. The current advancement in technology is a distinguishing feature of this era, with countries competing in scientific research fields to achieve the highest levels of prosperity for their people. The evolution from the old to the modern era is evident through continuous search for what is better and more advanced in all areas, with architecture being one of the most affected fields by technological advancement in all its forms, whether through the availability of engineering software, emergence of new materials and technologies for implementation, or the rise of artificial intelligence.

Since individuals spend more than 90% of their daily activities inside buildings, thermal comfort is a necessary requirement to be provided not only to maintain the health of the occupants but also to increase their productivity in work efficiently. Thermal comfort can be defined in various ways, such as the feeling of satisfaction with the thermal conditions inside a space. Some researchers, like Victor Olgyay, defined it in a more relatable way as the state where a person does not feel hot or cold when shifting their focus from work to the surrounding thermal conditions, leading to a feeling of discomfort [1].

Thermal comfort also encompasses concepts related to various scientific fields such as physics, material studies, and properties. The American Society of Heating, Refrigerating and Air-Conditioning Engineers defines”ASHRAE” thermal comfort in ASHREA Standard 55 as the psychological state achieved by an individual when feeling satisfied with the thermal environment. The perception of thermal comfort varies from one person to another based on their physical and mental conditions. Despite this, extensive laboratory information and data have been collected to provide statistical data that can identify conditions in which a higher percentage of occupants feel thermal comfort.Thermal comfort is not solely dependent on the indoor air temperature but is also influenced by factors such as relative humidity, average radiant temperature, air velocity, personal clothing, and the level of activity performed by the occupants **(Fig. 1)**. Since administrative buildings are spaces where individuals spend long periods, their internal environment significantly affects the comfort and productivity of users, which are essential elements for evaluating such types of spaces. Therefore, these buildings were chosen to study the impact of technological advancement on their internal thermal environment.

The current state of evolution, technologies, and construction methods of administrative buildings is a result of the efforts made to meet the needs of both occupants and the public dealing with this type of architecture, in addition to fulfilling the functional requirements of architecture in terms of aesthetics, strength, and utility.

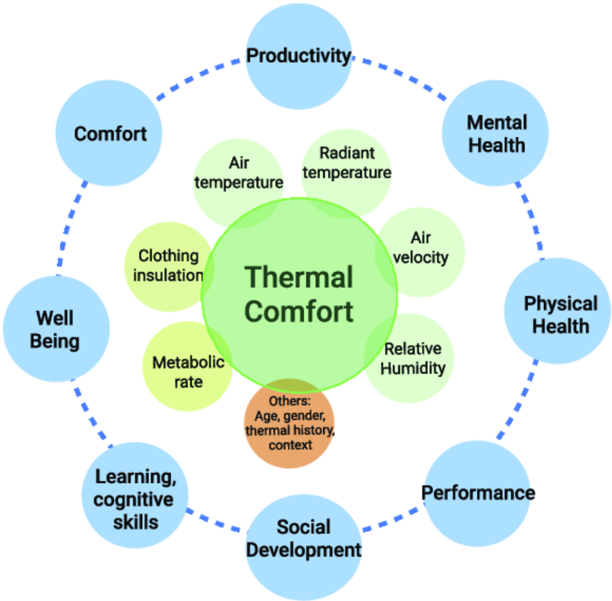

Fig. 1. Thermal comfort factors and their effects

2. Research Objectives

The main objective of the research is to monitor the impact of technological advancements, including modern environmental technologies, on achieving thermal comfort in administrative building spaces Achieving this main objective is based on achieving some sub-objectives such as:

2.1• Identifying innovative tools and solutions in the design and implementation of buildings, through which designers can create spaces that achieve suitable thermal comfort for users and improve the efficiency of their internal environment without resorting to mechanical means to achieve thermal comfort.

2.2• Clarifying the importance of utilizing modern environmental technologies in the design of administrative buildings to enhance their internal environment.

The contribution of research lies in reaching the relationship between modern technology and achieving thermal comfort in architectural office spaces. Most studies have focused on the impact of technological advancements on architectural design and architecture in general without delving deeper into studying their specific impact on thermal comfort in office buildings. Therefore, it addresses the gaps in this type of studies.

3. Research Methodology

The research methodology adopted to achieve its goal relies on two complementary methods that are specific to the scope of the research and can help achieve its objectives. The methodology is as follows:

Inductive Method: Relies on the induction of basic concepts related to technological development in its various forms and its impact on the internal environment of architectural spaces, specifically in achieving thermal comfort in administrative buildings.

Analytical Method: Through this method, the analysis of 5 samples designs implemented using modern techniques is conducted to understand how these modern environmental technologies are employed and their achievement in creating an internal built environment characterized by suitable thermal comfort.

Reviewing The efforts of architects and others in developing these buildings are countless, but what is being reviewed are the most prominent efforts that have achieved qualitative development and improvement in achieving thermal comfort in those types of projects :

Architect Frank Lloyd Wright designed the administrative building for the Larkin Company in 1904, which is considered one of the earliest office buildings to utilize interior space. The building, which consisted of six floors, featured a full-height atrium that received natural light from a glass ceiling, as shown in **Fig. 2**. The reason for this design was its proximity to the railroad and the noise from the trains, which led to the building being designed with a focus on the interior to provide a quiet working environment for the employees. The building was one of the first to use a central air conditioning system for both the large hall and the offices overlooking it through distribution lines .Despite representing modern construction, the building was demolished in 1949 [2].

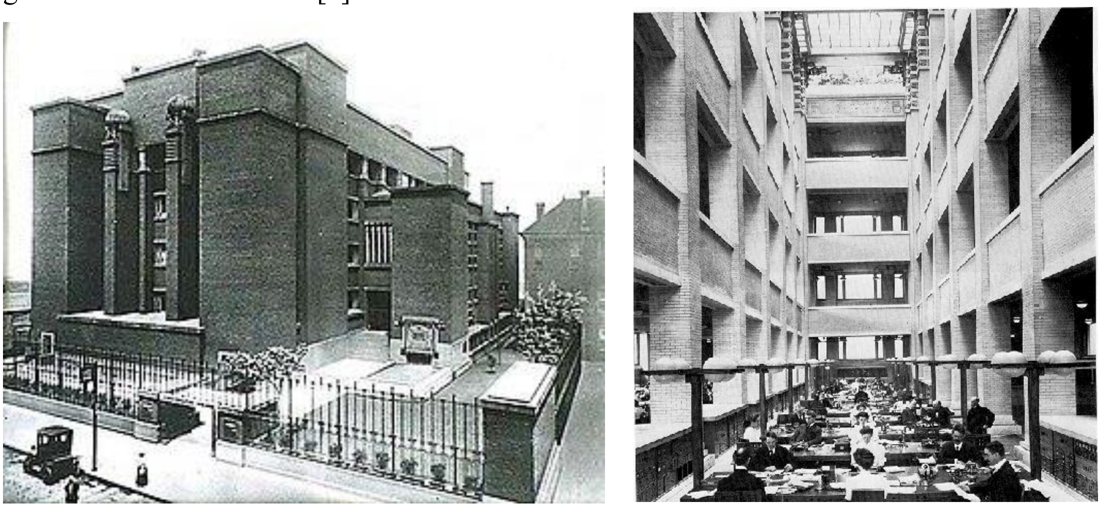

Fig. 2. Larkin building in Buffalo and the inner hall and offices.

Frank Lloyd Wright was able to create a new design for the structural columns supporting the roof of the main hall in the Johnson Wax Building. These columns were an open space occupied by employees, and were in the form of hollow conical columns resting on small metal bases, then expanding into a circular disk like an umbrella, as shown in **Fig. 3**. The spaces between the circles were filled with thin glass tubes that allowed filtered light to pass through without glare to provide the hall with natural light. Additionally, the building included the Research Tower, which consisted of 12 floors dedicated to offices [3].

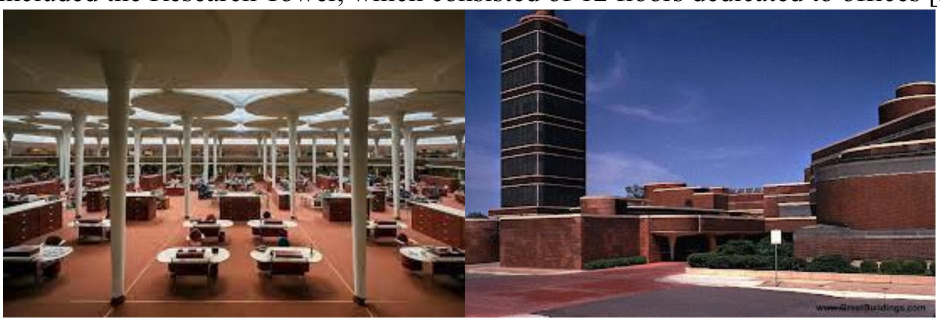

Fig. 3. shows Johnson's wax company building and shows the lab tower as well as the main lounge showing the cone columns.

The architect Le Corbusier with a group of architects including Oscar Niemeyer, designed the United Nations Headquarters in New York in 1947. This building is considered one of the most prominent administrative buildings in the world and consists of three main buildings: the Secretariat Building, which features a tall tower in the shape of a glass box with short sides, and the long sides covered in green glass divided by four belts for the various mechanical and electrical systems, as shown in **Fig. 4**. Next to the tower, there are two other buildings, the Conference Hall and the Media Building.In addition to the aforementioned building, Le Corbusier designed numerous administrative buildings around the world, such as the Ministry of Education and Health building in Rio de Janeiro, Brazil, with Oscar Niemeyer in 1936. This was his first skyscraper design where he dedicated his principles of architecture to high-rise buildings on columns, the boxy shape, the free floor plan, sun breakers, and the free façade figure [4].

Fig. 4. shows The United Nations Headquarters in New York and the building of the Ministry of Education – Rio de janeiro Brazil

The architects Mies van der Rohe and Philip Johnson collaborated on the design of the Seagram Building located in New York in 1958. Many architecture critics consider it an ideal building because the designers allowed for a clear view of the entire building by setting back a portion of the land as a plaza with fountains and pushing the bulk of the building to the back, contrary to the prevalent system in New York at that time of building on the boundaries of the zoning line, as shown in **Fig. 5**. The building rises into the New York skyline with its rectangular mass and transparent glass facade mounted on oxidized aluminum sections. The ground floor was utilized for commercial use in addition to a spacious lobby [3] .

Fig. 5. Seagram Building in New York, Meis Van Der Rohe.

The Lloyd's building in London is a prime example of the evolution of administrative buildings, as the architect Richard Rogers was able to design the building according to the technology available at that time in 1979. The building consists of a series of adjacent galleries, each of which is 16 meters high and overlooks a central inner courtyard. Each gallery can be used as an insurance trading hall or as an ideal office, and the spaces can be divided by coordinating the furniture. The building's services such as restrooms, entrances, and vertical circulation elements are placed on the outer wall of the building in six vertical towers, as shown in **Fig. 6**, which are clad in stainless steel, giving the building a shiny silver color. Rogers' design, with its open plan, allows natural light to penetrate deep into the space, creating a psychologically comfortable environment for the employees[5].

Fig. 6. Lioyds Building, London, Richard Rogers.

Another architect who achieved a significant development in the design of administrative buildings is Norman Foster. This development is not only in administrative buildings but in the majority of what Lord Foster designed, which is the integration of structural elements with architectural elements[7]. One of the most prominent examples of this is the Hong Kong and Shanghai Bank in Shanghai in 1981. The horizontal layout of the floor is almost free of internal columns, as shown in **Fig. 7**, allowing flexibility in spatial distribution as well as services and vertical communication elements located around the perimeter of the plan [6].

F. 7. shows the Hong Kong building in Shanghai -Foster.

The previous treatments were available during that time, followed by significant technological advancements in all fields, particularly in the field of architecture. In the following points, we will discuss the most important aspects of this development, including the emergence of smart building envelopes, the introduction of environmentally friendly building materials and treatments, and engineering software that plays a major role in environmental design and pre-emptive problem-solving before their appearance in the execution phase. Additionally, we will explore the emergence of artificial intelligence technology and its role in the evolution of the architectural field and its control over the thermal environment of spaces.

The smart envelope is a composition of building elements exposed to external weather conditions, performing a set of functions to respond to environmental variables to conserve the comfort of users with minimal energy consumption. In this envelope, the facade elements are adaptable through their self-regulating ability to modify and change their shape and structure. They represent a part of the smart building systems connected to other parts of the building outside the envelope area, such as sensors and actuators connected through command wires, all controlled by the central building management system, which represents the brain of the building [8] .

The double facade in the outer envelope consists of two separate parts connected by an air gap, which can be divided or undivided. Sun shading devices are often used between the parts of the envelope to achieve thermal comfort by controlling the thermal permeability of the facade in several ways, including controlling the shading of the facade using ventilated double facades, as well as the possibility of air permeability to the interior space through the use of operable windows operated by an automatic system [9]. An example of this system is the shows the Occidental Chemical Center at Niagara Falls, which was implemented in 1981 **(Fig. 8).** It consists of nine floors and was the first administrative building in the United States to use a double facade system, with louvers covering most of the facade, specifically between the outer and inner glass layers of the facades. These louvers control the opening and closing to prevent direct sunlight from entering the inner glass facade and are controlled by solar cells on the upper edge of one of these louvers in each part [10].

Fig. 8. shows the Occidental Chemical Center– Niagra Falls using the double casing system in the facades.

The smart envelope has desirable thermal properties both in summer and winter. The air gap contributes to increasing the temperature of the internal spaces when exposed to solar radiation in winter, and it helps to move hot air inside the building in summer. Smart envelopes come in several types, including the box facade, where the facade is divided into several horizontal and vertical divisions in the form of separate small boxes [10], as shown in **Fig. 9**.

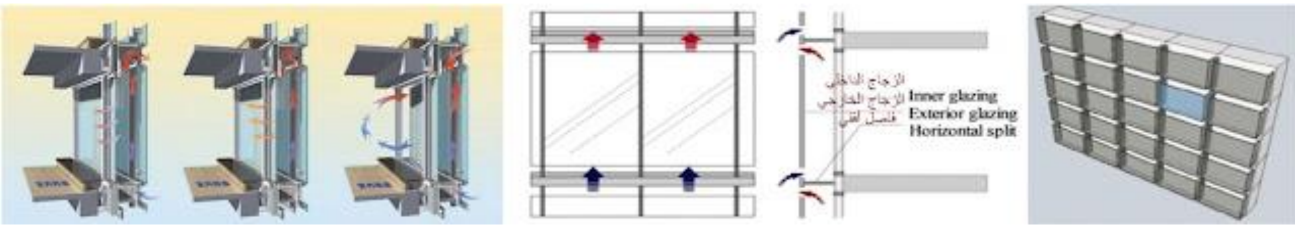

Fig. 9. The box facade structure system

Its concept is based on utilizing pressure differentials and air movement, where the air moves in a vertical column usually connected to a rotating vane under high pressure and speed, in addition to temperature differences. This causes the air to be drawn from inside the cavity using the negative pressure principle. The ventilation of the cavities relies on cross ventilation, where in this type of facades there are a group of box window elements located on the facade and connected by vertical columns located on the facade. The following building is an example of using the ventilated facade (box air column facade) to create pressure differentials that can be used for natural ventilation in tall buildings. As shown in ARAG building in **Fig. 10**, the facade that acts as an air column is divided in such a way that an 8-story facade acts as connected ventilation columns through flow openings to other facade units above and below with higher-level openings [10] .

Fig. 10. shows ARAG building

This type of facade is called an air passage facade. In this type of facade, the intermediate space between the outer and inner facade is horizontally divided at each floor level, and air inlet and outlet openings are placed in the passages in a radial pattern to prevent the air used in one floor from entering the floor directly above it [9]. Stadttor Building Dusseldorf, This building which was built in 1998 is an example of using an air passage facade, as shown in **Fig. 11**.

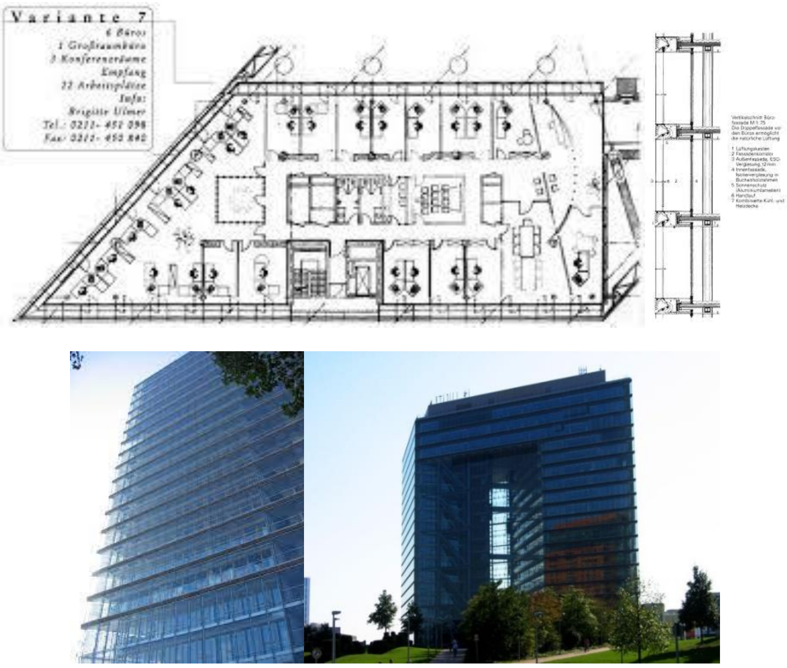

Fig. 11. shows Use the airway interface in Stadttor Building Dusseldorf

This type of facade is called "multi-story facade" and its concept is based on the presence of an unpartitioned air gap between the inner and outer facade. Large ventilation openings are created at the bottom of the facade to allow air to enter and exit the space between the two layers. Additionally, shading devices can be used between the layers of the facade in GSW Company. Shading devices have been integrated between the inner and outer layers of the western facade of the building, where it is protected by vertically moving perforated panels at an 18% ratio, as shown in **fig. 12**.

Fig,.12.shows GSW Company and Shadows on the west façade created a thermal buffer zone between the inside and the outside and the shape of the parachute above the tower.

Louvers facade consists of ventilation louvers, which are made up of transparent rotating slats operated by a motor. When these slats are closed, they act as a closed facade. However, when opened, the slats allow increased ventilation through the air gap between the layers of the facade. This technology is available as shown in **fig. 13** in glaxo welcome house west .

Fig. 13. shows the interfaces with ventilating chips in glaxo welcome house west

Moving facades are a remarkable architectural feature that can adapt their shape and orientation independently while controlling their opening and closing based on environmental conditions such as temperature, humidity, and wind. This integration of movable louvers into facade designs serves to mitigate solar heat gain and create a comfortable indoor environment[11]. An excellent example of this technology is the "One Ocean" building in South Korea, where vertical sunshades made of reinforced polymer sheets with fiberglass are utilized. These sunshades possess high tensile strength and low bending stiffness, featuring one rigid and one flexible edge to enable non-uniform bending, allowing light to permeate and provide effective indoor lighting.

The movable louvers in these facades are programmed to adjust in response to the sun's movement and optimal lighting, thereby minimizing solar energy gain, heat, and glare within the building. Sensors installed on the building's exterior surface enable the louvers to open and close throughout the day, responding to the sun's trajectory around the building, as depicted in **Fig. 14 .**

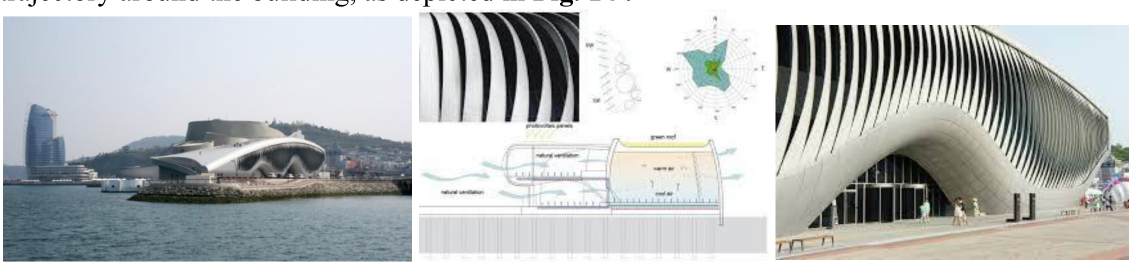

Fig. 14. shows the automatic motion solar fractures in One Ocean building in South Korea

There were many many contemporary systems to help to contribute to the development of a sustainable future have led to the integration of building materials with nanotechnology to improve their properties and provide them with more capabilities at the same time in terms of various insulation and energy saving and thermal comfort. The following is a review of some of the nanotechnology techniques used in facades and their impact on achieving thermal comfort.Transparent concrete is a cladding material made by integrating optical fibers with concrete and is capable of perceiving internal and external temperatures [12]. It allows sunlight to enter while avoiding ultraviolet and infrared rays and providing visibility through the glass at the same time, which reduces industrial lighting during the day, in addition to maintaining the thermal balance of internal spaces, as is evident from **Fig. 15** in Italian Pavilion in Shanghai .

Fig. 15. shows the Use of transparent concrete in Italian wing facadein Italian Pavilion in Shanghai

Fiber-reinforced concrete with glass fibers is a mixture of cement, sand, and nanomaterial additives, including glass fibers and a combination of alkaline materials that give it thermal and acoustic insulation properties. It is lighter in weight and provides better insulation, thus achieving thermal comfort inside buildings for the users. The Heydar Aliyev Center in Azerbaijan is one of the buildings where fiber-reinforced concrete with glass fibers was used, supported by a steel structure. This material helped in maintaining a comfortable indoor environment by reflecting heat, resulting in a comfortable thermal environment [12], as shown in **Fig. 16** .

Fig. 16. shows reinforced concrete with glass fiber in the interfaces of the Hyder Aliyev Center

Precast concrete is an important material used in cladding the exterior of buildings, known for its high thermal insulation. It consists of a double-layered concrete with an inner void filled with a heat-insulating material of no less than 2.5 cm. Precast concrete is available in the form of a single piece, blocks, or curved surfaces [11], as shown in **Fig. 17**.

Fig. 17. shows some tybs of pre cast concrete before pouring into the facades

Thermally insulated bricks rely on the use of nanotechnology in binding the particles during the mixing process to achieve the highest possible material homogeneity. This type of brick is characterized by its energy renewal capability. For instance, a cubic meter of zeolite spread over an area of 250 square meters provides a 60% increase compared to any other material used for moisture retention or heat exchange [11].Sun protection glass is an innovative application of nanotechnology, integrating glass with the building in several ways, such as the photochromatic method. In this method, the heat of the sun triggers the darkening process, allowing the windows to significantly reduce heat load. This type of glass achieves thermal transparency, heat protection, energy conversion, and heat storage by storing solar radiation in winter and reflecting it in summer, as shown in **Fig. 18**.

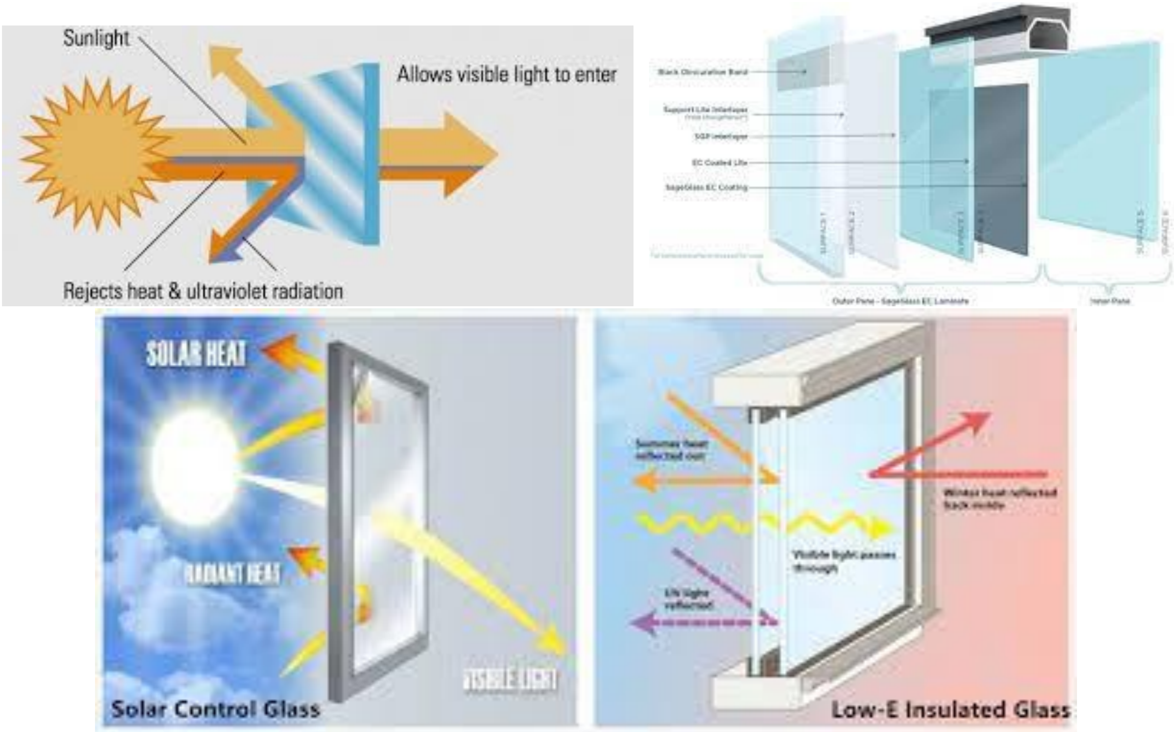

Fig. 18.shows different types of glass

The use of computer applications plays a significant role in helping to define and understand the environmental behavior of buildings.These applications are no longer limited to just climate analysis, but now also include the study of the complete environmental behavior of buildings. Many simulation programs have emerged to evaluate the performance of buildings throughout the year by representing the heat exchange between the interior and exterior spaces, as well as the environmental behavior such as sun movement, wind, light, shadows, and thermal properties of materials[13].
Environmental simulation programs are essential for enabling designers to assess different alternatives to select the best options for energy efficiency or providing a suitable environment. They also help in illustrating sudden changes in different energy quantities. These programs vary in terms of their methodology, inputs, and outputs. They are used as modeling tools to evaluate the environmental performance of buildings by trained specialists, based on globally recognized standards. The ultimate goal is to achieve buildings that provide the required thermal comfort for the users, and serve as a display tool for presenting the suitability of environmental solutions and their development to understand the building's behavior, facilitating decision-making by designers as shown in **Fig. 19** .

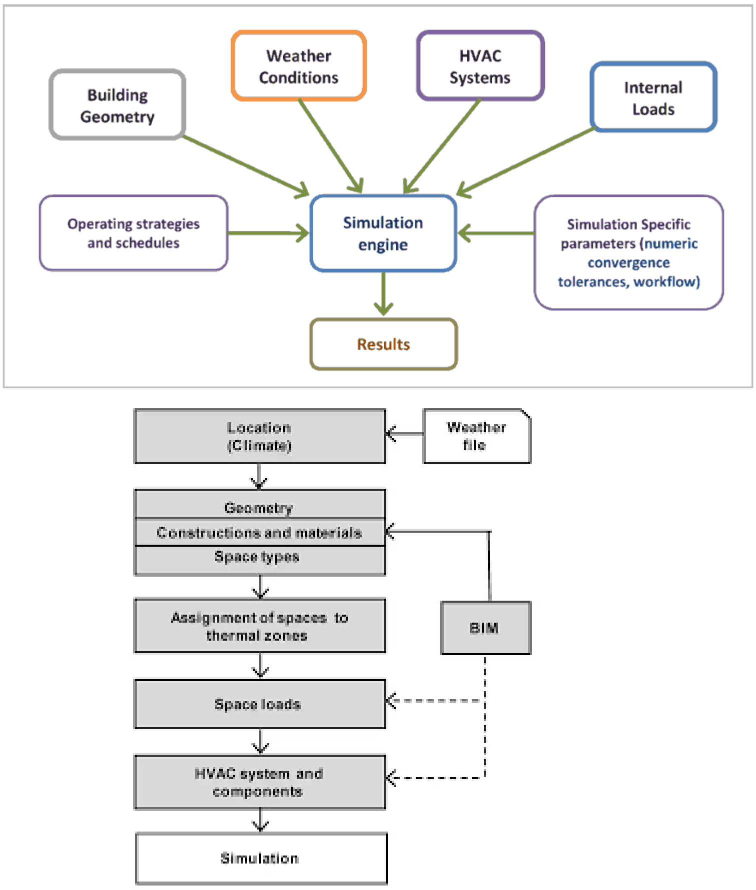

Fig. 19. shows Building performance simulations

And consider simulation programs as one of the important and necessary forms of technological advancement to keep pace with the advanced world in its sciences. They help save money and effort, and take less time to evaluate the effectiveness of the design in reality. It is considered a high-level technological advancement. It is also considered an advancement in the field of sustainable and environmentally friendly buildings, green architecture, and smart architecture, which are among the most prominent challenges in the field of architecture today. They are among the most important tools used in the field of clean and renewable energy in terms of their ability to determine the energy produced and consumed, which has increased their scientific effectiveness and efficiency.Simulation programs provide virtual experiments to test the proposed alternatives with a realistic vision and determine the nature of usage based on the type of outputs and conclusions. They are used technically to calculate the required energy and the energy consumed before implementation in order to provide support for designers to make optimal decisions in energy use. They are also used environmentally as a design tool that enables designers to simulate the environmental performance of the building through architectural drawings and diagrams to calculate the locations of natural lighting inside the building, internal heat, ventilation, and so on. They help in the effective application of environmental system strategies by simulating energy consumption for the heating, ventilation, and air conditioning system.There are many different simulation tools, each with a specific use to predict the behavior of the building according to variable inputs to reach the best suitable solutions for the entire building or for a specific part of it. Some of these programs include DesignBuilder, eQuest, Bently Tas Simulator, Autodesk Ecotect, Plus Energy, Graphisoft Eco Designer, and Autodesk Green Building Studio and many others[14] .With the expansion of the use of modern technology, it has become an important factor in the global trend towards creating a clean environment and reducing emissions in light of current international commitments to these goals. Technology supported by machine learning models or artificial intelligence (AI) now plays a clear role in smart buildings, where the program automatically integrates with the building components to transform it into a smart building that measures all types of emissions. Through smart applications, all measures are taken to reduce emissions.

In practice, artificial intelligence can collaborate with negative design techniques to improve the direction of the building, window sizes, shades, and increase natural light and ventilation.

It can also assess vast amounts of data from past projects, architectural patterns and environmental aspects using automated learning algorithms to provide design solutions that meet specific requirements. With the help of this capability, architects can investigate a wide range of design options and make defensive options based on data-based insights.

They can also introduce the desired results, including spatial needs or energy efficiency objectives, and obtain a range of design capabilities that meet these standards using generational design, a technique supported by artificial intelligence. It helps to quickly provide a wide range of design forms, providing architects with a variety of options to choose from. This method not only accelerates the design process, but also encourages innovation by introducing new concepts that may not be reached by traditional means.

Artificial intelligence is necessary to enhance building efficiency because it can analyse data from several sources, such as environmental factors, tenant behaviour and energy use, and can predict how buildings behave in different environments through the use of predictive analyses, which enable architects to create flexible and energy-efficient structures.When artificial intelligence is combined with building information modelling (BIM), data analysis and simulation are provided in real time, leading to greater improvement in performance. AI systems have the ability to predict maintenance requirements, detect any design defects and optimize resource allocation, leading to strong and effective structures. For example, artificial intelligence can recommend the modernization of heating, ventilation and air conditioning systems (HVAC), isolation, or natural lighting to improve comfort and energy efficiency.

In the field of architectural design and construction, artificial intelligence technologies such as generative design and genetic algorithms offer immense capabilities for architects and property developers. They help in providing innovative and advanced architectural solutions in record time, which cannot be achieved using traditional methods. Although generative design is not new to architectural engineering, its use has been limited due to the complexity of dealing with it, as it requires the analysis of massive amounts of data to create optimal designs, necessitating specialized architectural engineering experts. The Heydar Aliyev Center, designed by Zaha Hadid as shown in **Fig. 20** using generative design, is a prominent example of creativity in the field of architectural engineering using artificial intelligence. The center is renowned for its innovative and modern design, and Zaha Hadid is one of the leading architects who uses advanced design technologies [15].

Fig. 20. shows Heydar Aliyev Center, which was designed using generator design based on Artificial Intelligence techniques to analyze hundreds and thousands of data.

4. Analytical study of the case study buildings

In this part of the research. An analytical study of five case studies was conducted by examining the modern environmental technologies implemented in them and their environmental interaction with the surrounding environment. Each technology was analyzed in terms of its components and its application in the building, as well as its impact on providing a built environment characterized by suitable thermal comfort for the users, and the resulting energy savings in lighting, cooling, and heating. When selecting the case studies, consideration was given to their differences in external shape, size, and the material used for the external facades, as well as the variation in the environmental technologies used in each case study, in order to review as many modern environmental technologies as possible**.**

4.1. Hearst Tower at New York City for architect Norman Foster.

The Hearst Tower is located on 8th Avenue in New York City, near Columbus Circle in Midtown Manhattan. It is a 46-story building that began construction in 2003 and was completed in 2006. The tower stands at a height of 182 meters and features a distinctive triangular steel frame in a geometric shape. It represents the first environmentally friendly (green) building in New York and is the first high-rise building in the city to achieve a gold LEED certification.

The building's four facades are made of double-layered low-emissivity glass, with an air gap between the two layers to reduce solar radiation infiltration and, consequently, the cooling load, while allowing natural light to pass through. The glass material used in the construction also facilitated the creation of notched corners on the building, which helped in casting shadows. This demonstrates the role of modern technology in assisting the designer in choosing the elements used in the building, such as the type of glass that reduced energy consumption in the interior spaces by enabling natural ventilation for approximately 75% of the year. The building was designed to consume 26% less energy than the minimum requirements for New York City, compared to the total energy consumed by a similar building of the same size and shape using traditional facades[16]. This was achieved through the use of water pipes for thermal control under the atrium floor, an air shaft to move air within the tower spaces, and a water cascade to harness heat within the glass spaces, as illustrated in **Fig. 21**.

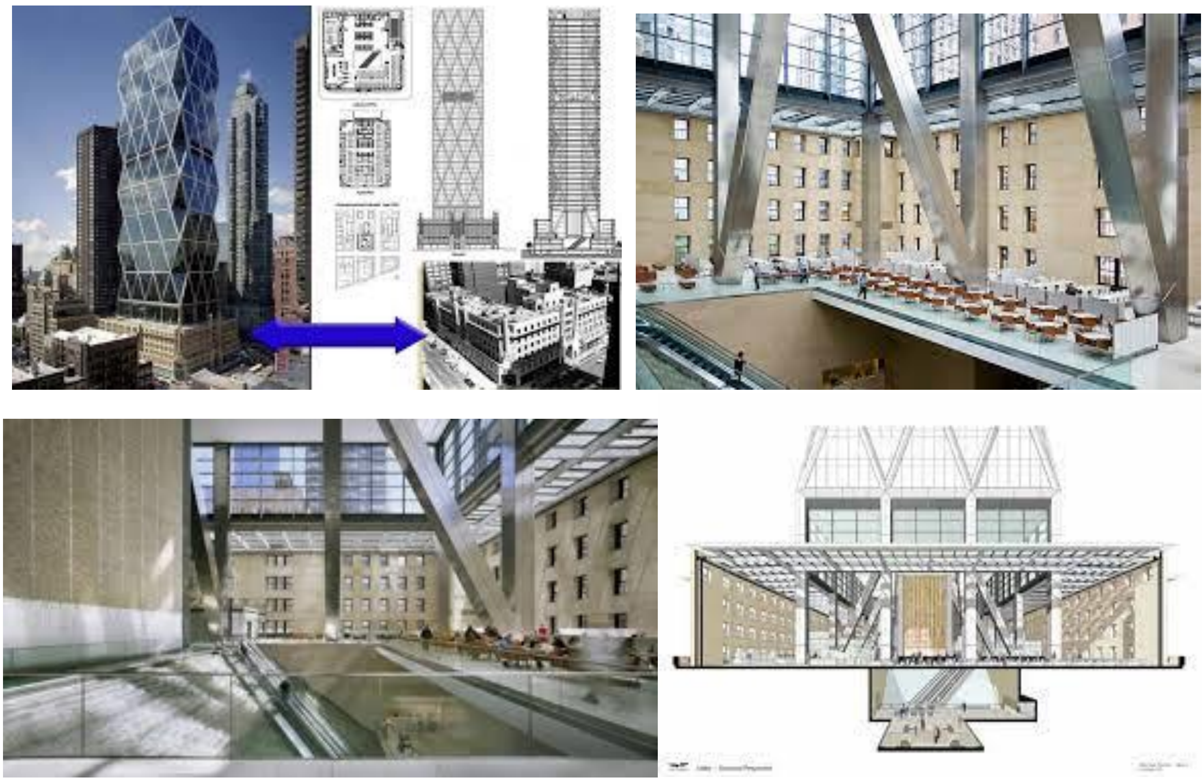

Fig. 21.shows Hearst Tower and The inner courtyard, the cold waterfall in the lower floors, the geodesic steel shape, and the formation of the mass.

4.2. Suiss Re Tower, London City, Norman Foster.

Suiss Re Tower is located in the heart of the British capital London. It consists of 40 floors and is 180 meters high. Construction began in 2001 and was completed in 2003, and it was opened in 2004 [17]. In the same year, it won the highest architectural award in the United Kingdom, which is a prize from the Royal Institute of British Architects.The building achieves high energy efficiency and thermal comfort by using natural lighting and ventilation provided by the circular glass facades. The external facade of the building consists of two glass layers with an air cavity in between, where the air moves electronically using external weather sensors that monitor temperature, wind speed, and sunlight levels. The sensors control the windows to open and close when the outside temperature is between 20 to 26 degrees Celsius and the wind speed is less than 10 km/h, to ensure the appropriate indoor climate for the building occupants, **(Fig. 22)**.

In addition, the installation of operable windows allowed for the entry of fresh natural air into the internal spaces, greatly contributing to a unique natural ventilation system and reducing the building's reliance on industrial air conditioning. This, in turn, led to a significant reduction in energy consumption, up to 50% compared to a similar building in size and shape using traditional facades. The building's shape also provides natural light and external views for the building's occupants [11] .

Fig. 22. shows Suiss Re Tower, London City

4.3. Commerzbank In Frankfurt, Norman Foster

This tower is located in Frankfurt, Germany, and is designed by Norman Foster and consists of 56 floors, which were completed in 1997 and were the tallest building in Europe at the time and remained so until 2005.The interface between the outer environment and the interior environment (manufacturing) is such that the interior vacuum eventually appears as an integral part of the external environment. The hung gardens strategically located throughout the building have combined the elements of sustainable design, as well as the aesthetic form and natural ventilation, where the plants have been used in the atrim in order to provide the office with daylight and natural ventilation. The location of the parked gardens changes according to the geography of the building. This confirms the role that green cover plays in reducing the temperature of the buildings. This shows that building technology plays an important role in addressing climate change through energy savings and improving thermal insulation and ventilation quality.

The outer envelope of the building consists of double-layered glass, with the outer layer being thermally treated, resistant, and heat-insulating, and the inner layer being low-emissivity glass. In addition, there is a 16 cm [18] gap between the two layers, with openings in the outer layer allowing fresh air to enter the gap, enabling individual regulation of ventilation by opening and closing the windows according to users' preferences throughout the year. Furthermore, the double-layered envelope acts as a thermal insulator in winter, allowing solar penetration, and in summer, it provides solar control to prevent temperature rise.

The building was designed to be naturally ventilated for 60% of the year, with the expectation that this approach would reduce energy consumption by up to 50%. However, studies have shown that the tower actually consumes 20% less energy than originally projected, as the building users have extended the period of natural ventilation to 85% compared to the 60% assumed during design (**Fig. 23)**.

Fig. 23. shows commerzbank And the treatments that have been done, such as the use of double glass and the inner gardens of the tower

4.4. Sea towers in Abu Dhabi .

The Sea Towers project is located at the intersection of Happiness Street and Al Salam Street in the city of Abu Dhabi, the capital of the United Arab Emirates. Each of these two towers has 29 floors and a total area of 70,000 square meters, with a height of 145 meters. The construction of both towers was completed in 2012 and they were designed by Idas and built by Al Futtaim Carillion. The project won the Emporis Skyscraper Award in 2012 and is considered one of the best architectural designs in terms of innovation, sustainability, and environmental compatibility [19].

The towers feature a fully glassed exterior facade, but the outer surface is covered with a protective structure consisting of 2000 honeycomb-like umbrellas that open and close automatically according to the movement of the sun, helping to reduce the heat inside the towers by half. A set of solar panels on the roof is used to heat water. The external structure is two meters away from the glass structure of the building and is designed as an independent framework. Each triangle is coated with fiberglass and programmed according to the movement of the sun. At night, the umbrellas fold to reveal the building's main glass facade, and as the sun rises in the early morning in the eastern region of the building, the umbrellas in the eastern area open. As the sun moves to cover other areas of the building, the umbrellas follow its movement and open accordingly. This concept is inspired by "mashrabiya," which are geometric wooden screens used to fill the windows of traditional Arabian architecture since the 14th century, providing shade and privacy while allowing an external view at all times as shown in **Fig. 24**.

Fig. 24.shows Sea Tower Abu Dhabi

4.5. The Edge building, Amsterdam

The Edge building is located on an area of 40,000 square meters and is characterized by a combination of energy-efficient systems and technologies for energy use and generation. It has won the award for the most sustainable office building in the world[20]. The building's design is based on the movement of the sun, with solar panels covering its entire southern facade and roof to generate enough electricity to meet the building's needs. The northern facade is covered with glass panels to provide natural light during the day as shown in **Fig. 25.** The building also incorporates cooling and heating systems that utilize geothermal energy storage, taking advantage of the sun's path. This system uses underground connections, with one for heating and another for cooling. The building's lighting system is connected to motion sensors, activating when motion is detected in an area. The lighting, heating, and cooling systems can also be connected to smart devices through a dedicated application, allowing employees to control room temperature and lighting intensity as needed. The building includes systems for collecting rainwater and reusing it for watering plants or in the bathrooms.

Fig. 25. shows The Edge building which based on the design of the motion of the sun

The following table **(Table. 1)** shows the tools, materials and techniques used to achieve thermal comfort in the case study buildings .

Table. 1. shows the tools, materials and techniques that have been used to achieve thermal comfortt in the projects under study

projects	**Hearst Tower, New York City**	**Suiss Re Tower ,London City**	**Commerzbank, Frankfurt**	**Sea towers, Abu Dhabi**	**The Edge Building,Amsterdam**
					
Techniques and materials used	-Low emission double glazed facades. -Ease of making fractures on the four corners of the building, which helped to cast shadows. -Choose a glass quality that reduces energy consumption in internal spaces by helping them rely on natural ventilation. -The building is designed to consume 26% less energy than the minimum New York City . -The use of water pipes for thermal control under the floor of the atrium and an air tower to move the air inside the spaces.	- The use of natural lighting and ventilation provided by circular glass facades . - The external façade of the building consists of two glass layers between which there is a cavity in which the air moves electronically using external weather sensors. - The sensors are controlled by the computer to open and close the windows. - The installation of openable and closed windows allowed fresh natural air to enter the interior spaces. - Reducing the dependence of the building on industrial air conditioning, which in turn led to reducing energy consumption by up to 50%.	-Strategically placed hanging gardens have been used throughout the building and are a source of natural ventilation. - The outer shell of the building consists of double glazing consisting of two layers, the outer layer of heat-treated. resistant and heat-insulating glass and the inner layer of low emission glass. - The double-layer casing acts in winter as a heat insulator allowing solar penetration and in summer it provides solar control to prevent overheating. - This building was designed to be naturally ventilated for 60% of the year.	- The two towers feature a full glass exterior façade. - The exterior is covered with a protective structure of 2,000 hives-like umbrellas, which automatically open and close according to the movement of the sun . - Each triangle is coated with fiberglass and programmed according to the movement of the sun. At night, the umbrellas remain folded, and when the sun rises, they open, and whenever the sun moves to cover other areas of the building, the umbrellas follow them and open according to the movement of the sun. - The external structure is two meters away from the glass structure of the building.	-It features a combination of and technologies for energy efficiency, use and generation. - The building relies in its design on the movement of the sun, as it contains solar panels that completely cover its southern façade and roof, in order to generate enough electricity to meet the needs of the building. - The building contains cooling and heating systems through underground energy storage taking advantage of the sun's path . - The lighting system and the heating and cooling system are characterized by the possibility of connecting to smart devices through systems a special application.

5. RESULTS AND DISCUSSION

It is evident from the analysis of the case studies, which all share the characteristic of having a second skin composed of full-height glass windows, that the designers have succeeded in addressing several important issues. These include preventing energy loss due to heat transfer through the facades, harnessing solar radiation, and ensuring sufficient natural light transmission throughout the day to reduce the use of artificial lighting. Additionally, the case study facades have played a significant role in shaping the external facades, as a key and influential element in the indoor environment, particularly in terms of thermal comfort. The study has also shown the use of alternative modern technologies to improve building envelopes to enhance their internal environment

Despite the differences in designer, location, climate, and other influencing factors for each case, the results show that they shared some main objectives. These include achieving a suitable thermal comfort environment for users and providing the possibility of natural ventilation, as well as reducing electricity consumption for lighting, air conditioning, and cooling by maximizing natural light and ventilation in the indoor environment

As a result of technological advancements, modern scientific engineering standards have emerged, allowing for a realistic judgment of the final architectural product's efficiency and its achievement of human comfort. This has enabled the architectural work to be evaluated scientifically, linked to art, as a mechanism of the architectural product, ultimately achieving comfort as the final result .

In conclusion, technological advancement can be seen as a double-edged sword. It can drive architecture towards success as an environmentally linked architectural product, or it may cause architecture to fall behind the environment due to the absence of science or art in the final product.

The facades with modern environmental technologies are considered a form of technological advancement in the field of architectural engineering, as they respond to different environmental conditions to ensure suitable thermal comfort for users by optimizing the use of available natural energy for lighting and ventilation with high efficiency.

The outer shell regulates the thermal effects between the external and internal environments through heat transfer behavior, acting as a thermal regulator for the building. Therefore, the more dynamic and flexible the shell, the more it responds to external and fluctuating climatic influences. It can reduce the thermal loads on the building, thus achieving maximum thermal comfort in its indoor environment.

It has become possible to create contemporary and environmentally friendly structures that also belong to the local environment by achieving integration between the natural environment and contemporary technology. This is done by leveraging the climatic characteristics of the natural environment and transforming any negatives into positives through the use of advanced technological systems to achieve highly energy-efficient structures.

Conclusions

Through technological advancements, humans have been able to control natural laws and environmental data. Building technology has succeeded in developing techniques and materials to be a tool for designers to deal with natural laws to work on human comfort without neglecting achieving artistic and aesthetic formation at the same time, supporting the integration of architectural work.

There are many positive results that affect the design and improvement of administrative buildings resulting from keeping pace with technological developments. For example, from an environmental perspective, clean energy can be provided to buildings by using renewable energy sources instead of traditional energy. However, there are also some negative results that can be obstacles when applying smart systems in advanced administrative buildings, such as the high initial cost of developing the building into a smart building and the difficulty of comprehensive development for many buildings due to the lack of readiness to achieve a qualitative leap in the building, in addition to the difficulty of providing clean energy for the building as a whole and the continuous fear of hacking into the internet-connected building systems.

The designer should strive in their building designs to achieve the highest suitable quality levels to enhance the built environment and the thermal comfort of the users. To succeed in this vision, the indoor environmental needs should be taken into account in order to promote diversity and improve air quality.

It is essential to study the surrounding conditions of the building and the factors that affect the increase in heat loads before starting the design process in general, and the facades in particular, as windows are a source of energy drain and are linked to the excessive energy needs of the building.

The selection of modern environmental technologies intended for use in buildings should be subject to an analytical study to determine the compatibility with the climate in which the building is located and to assess its ability to meet the environmental requirements of the interior space, especially with the diversity of types and forms used, the variation in materials and their ability to withstand heat, as well as their method of use and cost.

Achieving human coexistence with their environment through the building has been the architect's task throughout the ages, surpassing the fulfillment of human physical requirements from the environment to achieve sensory and emotional requirements associated with the environment.

Developing a culture of preserving the natural environment and the built environment to achieve the elements of satisfaction for basic needs such as thermal, visual, and psychological comfort for current and future generations.

Supporting educational curricula for engineering students and the necessary local standards for application during the study period, along with supporting legislation, laws, and regulations with the establishment of strict requirements and mandatory laws to create a suitable environmental field. Additionally, the presence of state encouraging policies with the creation of mechanisms for application and coordination among the responsible authorities and incentive policies from decision-makers to support the environmental direction in design and operation.

Continuous research for means and methods that make buildings responsive and interactive with what is happening inside and outside them, and any other influences, to reach the highest level of productivity by employing available and accessible technologies, methods, systems, and media. This includes the possibility of developing and updating existing buildings in a way that allows them to continue to be compatible with and responsive to new buildings with their modern advanced systems.

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