Studying the impact of the role of nanomaterials technology in developing the performance of buildings and their effect on the architectural formation

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- **ملخـــــــــــص البحث:**

تعتبر دراسة تأثير تطبيقات تقنية مواد النانو فى العمارة ودورها في تطوير أداء المباني ومردود ذلك على التشكيل المعماري هو ثمرة عقود من البحث والتطوير لتقنيات النانو وتطبيقاتها للمباني. ولهذا يركز البحث على دراسة أنواع وأشكال مواد النانو المختلفة ومجال استخداماتها في التشييد والبناء ومواد التشطيب المختلفة. بالإضافة إلى دراسة أسس ومحددات تطبيقها في العمارة وتأثيرها على الشكل العام وتطوير أداء المباني. والذي يشمل تحقيق النواحي الوظيفية والاقتصادية والارتقاء الجمالي والبيئي للمباني. كما يتناول توضيح دور تطبيقات تكنولوجيا النانو فى مجال توفير وترشيد استهلاك الطاقة والحفاظ عليها وزيادة فعالية مقاومة الحريق وتنظيف المباني ذاتياً وتقليل التكلفة والصيانة وإطالة العمر الافتراضي للمباني، وتمت مناقشة فوائد تطبيق مواد النانو في العمارة بشكل عام ومدى تأثرها بها. فهي تؤثر بشكل اساسي على المباني من حيث الوظيفة والأداء والتشغيل والتشكيل والبيئة الداخلية والمحيطة بالمبنى وتساهم في الحصول على المباني ذات التشكيلات المعمارية المناسبة والأداء العالي والتكاليف المنخفضة لتحقيق تصاميم معمارية مميزة ذات مظهر جمالي فريد. وأخيرا يجب على المصمم المعماري الانتباه إلى اختيار المواد النانوية المستخدمة في المباني وأماكن تطبيقها لإعطاء تشكيلات وواجهات مميزة. وبشكل خاص يؤدى زيادة التوعية بالتقنيات الحديثة وتكنولوجيا النانو إلى تحسين كفاءة أداء المباني.

Abstract

The study of the impact of nanotechnology applications in architecture, its role in developing building performance, and its impact on architectural formation is the result of decades of research and development of nanotechnologies and their applications for buildings. Therefore, the research focuses on studying nanomaterials' different types and forms and their uses in construction and various finishing materials. In addition to studying the foundations and determinants of their application in architecture and their impact on the general form and the development of building performance. This includes realizing the functional and economic aspects and the aesthetic and environmental upgrading of buildings. It also clarifies the role of nanotechnology applications in saving and rationalizing energy consumption, conserving it, increasing the effectiveness of fire resistance, self-cleaning buildings, reducing costs and maintenance, and extending the life of buildings. The benefits of applying nanomaterials in architecture and their impact on them were discussed. It mainly affects buildings in terms of function, performance, operation, formation, and the internal and surrounding environment of the building. It contributes to obtaining buildings with appropriate architectural figures, high performance, and low costs to achieve distinctive architectural designs with a unique aesthetic appearance. Finally, the architectural designer must pay attention to the selection of nanomaterials used in buildings and the places of their application to give distinctive formations and facades. Increasing awareness of modern technologies and nanotechnology leads to improving building performance efficiency.

Keywords

Energy saving, nanotechnology, nanomaterials, nanocoating

1. Introduction

Nanotechnology is one of the minor standard units that man has been able to measure and produce something tangible that serves humanity. The emergence of this technology and composite materials significantly changed our understanding of the present and the future through its impact on architecture, which led to a development in the architectural formation of buildings—creating new means of expression and considering environmental and economic constraints. Nanotechnology has helped with a massive leap in all branches of science and

engineering, especially in building, construction, and architecture, by rearranging the particles of matter next to each other. Unique methods of micro-scales and most countries have advanced their scientists and capabilities in producing those materials and products that cannot be. All of them are due to rapid development.

Nanotechnology began with the American physicist Richard Feynman with the idea of controlling things at a microscopic level, the size of which does not exceed the size of a bacterial cell. For the house, building materials are used with it, new designs, features, features, features, houses buildings, or building materials use, building materials are used. From here, the latest nanomaterials used in construction and some of their newly emerging capabilities will be presented at the end of the twentieth century and how nanotechnology developed traditional building materials and improved their performance, as well as the emergence of new materials.

1.1. The importance of research:

Nanotechnology is considered one of the essential fields nowadays because of its unique and new characteristics, which will change the concept of construction, positively affect buildings in the future, and contribute to the development of architecture and urbanism. The importance of the research is to clarify the impact of nanotechnology applications on buildings in terms of the quality and properties of the materials used, architectural formulation and formation, as well as cost considerations, extending the lifespan, reducing maintenance, and conserving and saving energy.

1.2. Research problem:

The problem of the research lies in that the traditional building methods and materials used in their conventional and repetitive form in many buildings had no effect on the architectural formation and aesthetic appearance, as well as determining these materials and their effectiveness in human comfort, as well as the low quality of surfaces and the efficiency of buildings, the increase in maintenance costs and the short lifespan of buildings, It also does not help to save energy, and through the research shows the importance of using nanomaterials and the technology used in buildings to confirm that they are highly efficient buildings that can avoid the resulting defects and problems.

1.3. Research questions:

The research attempts to answer the following research question:

What is the role of nanomaterials technology in developing the performance of buildings and their impact on architectural formation?

1.4. Research Objectives:

1.4.1. The main objective:

Raising the efficiency of buildings using nanomaterials technologies and determining the extent of the impact of nanotechnology on them from the following points: (operational standards, aesthetic standards, economic standards, energy saving, self-cleaning, maintenance, and environment-friendly - lifespan).

1.4.2. Sub-objective:

The research aims to identify new materials with unique characteristics that affect buildings' architectural formation and aesthetic appearance. It also aims to raise awareness among

architects of the need to pay attention to the application of nanomaterials in architecture, which may help change the general appearance of buildings.

1.5. Research hypothesis:

The use of nanomaterials technology has a significant impact on changing the architectural formation and formulation of buildings, and it has the advantage in terms of functionality and economic returns in the long run. Besides, finding architectural solutions in building and construction, as it achieves architects' distinctive designs with a unique aesthetic appearance, will significantly reduce costs, extend the life span of buildings, reduce maintenance, and help to save energy.

2. Research Structure:

2.1. What is meant by nano?

Nano means something very small or precise in size (infinitely small things). The word "Nano" appeared at the beginning of the Greek era, as it is derived from the word "Nanos" in the ancient Greek language and means "Midget" in English, meaning dwarf. In science, it implies nano One billionth of a meter (i.e., one throne-thousandth lion) and in numbers (10-9 m), or one-millionth of a millimeter [14].

2.2. Nanometer scale:

A nanometer is a unit of longitudinal measurement like other recognized units of measurement. The nanometer measures tiny things that can only be seen under an electron microscope and not seen with the naked eye.

2.3. Nanoscience:

It is the science that studies and is concerned with dealing with materials at their atomic and molecular levels at a scale not exceeding 100 nanometers, and is concerned with classifying molecules and atoms, studying their distinctive properties of nanomaterials, and studying the phenomena associated with reducing their size to explain them for different properties and specifications [7].

2.4. The Nano Technique:

It is the technology that gives us the ability to control materials directly. Its concept also depends on particles whose size is less than one hundred nanometers that give the material new properties and behaviors, and this is because these particles (which are smaller than the characteristic lengths associated with some phenomena), by manufacturing, monitoring, measuring and studying its characteristics, and deals with atomic assemblies ranging from five atoms to a thousand bits, as nanotechnology has dimensions much less than the dimensions of bacteria and living cells [13].

2.5. Nanomaterials:

Nanotechnology has affected architecture in terms of building methods and finishing materials, so many types of Nanotechnology have been integrated with architecture Table 1. Nanotechnology has an impact on materials and energy properties, which led to a noticeable difference in the methods of thinking and architectural design, and nanotechnology was used. In construction and building to reduce the cost of construction, preserve the building materials resources, and open modern areas to save energy and protect the environment [18].

The savings in the use of these technologies reached (25%), in addition to the endurance capacity and the distinct characteristics of the building materials and their superior ability to withstand unusual weather, which contributes to the settlement of these materials in desert places and places with high temperatures, humidity or frost. Or other various environmental features.

Table 1. The shapes of nanomaterials [17]

Different types and forms of nanomaterials	
Nanotubes	Hollow tubes Each tube has a diameter of fewer than 100 nanometers and maybe thousands of nanometers in length. Examples are carbon nanotubes, silicon tubes, and titanium tubes.
Nanorods	They are like nanotubes, except they are solid and shorter than them, such as gold and platinum rods.
Nanocomposite	It results from distributing or diffusing nanomaterials inside ordinary materials; for example, carbon nanotubes are dispersed and spread inside some plastic materials to obtain—nanocomposites with superior properties.
Thin Films.	It is a thin layer of a specific material with a thickness of fewer than 100 nanometers, and these thin layers are used in the field of semiconductors such as silicon and gold alloys.
Nano Particles	It has several shapes; one of its dimensions is less than 100 nanometers and may be a cube, spherical or oval.

2.6. Composite Materials:

Recently, interest in composite materials as engineering metamaterials increased due to their unique properties. This interest was demonstrated in construction facilities require [24].

Composite materials consist of merging materials with different properties, and the purpose of this merging is to produce new properties that were not available in the original materials. Figure (1) shows the composite material, and these materials have proven successful in different types of composite materials that affected architecture [21]:

1. Glass-Fiber-Reinforced-Polymer (GFRP):

Composite materials are defined as materials that consist of a mixture of materials that share the required properties in there. It is a mixture of polymers and other materials with high strength (Stiffness) such as glass fibers or boron, examples of which are: polymers shown, glass fibers, plastics (GFRP), And Glass Fiber Reinforced Concrete (GFRC) are panels used architecturally in facades. The meetings consist of layers of high-performance grains of white cement concrete, characterized by durable and thin materials ranging from (mm to cm). It can also be cast separately to form the curved shapes required by design. Figure (2) shows the glass fiber-reinforced polymer and its uses, and Figure (3) shows the Heydar Aliyev Cultural Center in Baku, where the glass fiber-reinforced polymer is applied [15].

2. Carbon-Fiber-Reinforced-Polymer (CFRP):

Carbon fibers are polymers of carbon fibers and can replace iron in reinforcing work. Still, they are characterized by a very high tensile resistance that may reach five times that of iron, meaning that a carbon fiber segment does not exceed a few millimeters thick that can replace a rod. It is made of iron with a large thickness in tensile strength, as shown in Figure (4), a carbon fiber-reinforced polymer [9].

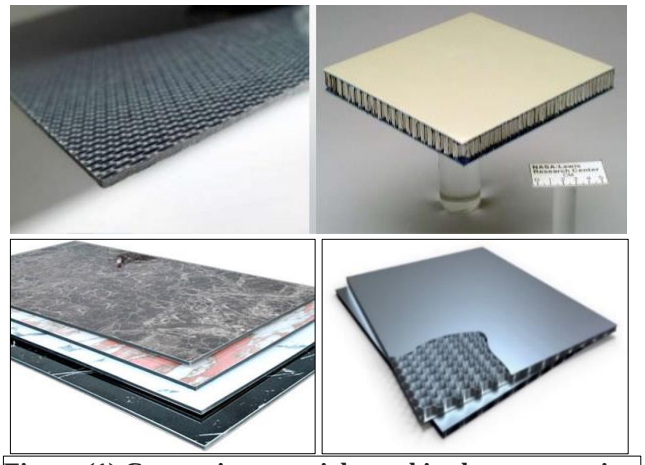


Figure (1) Composite materials used in the construction and finishing (aluminum, marble, wood) [21]

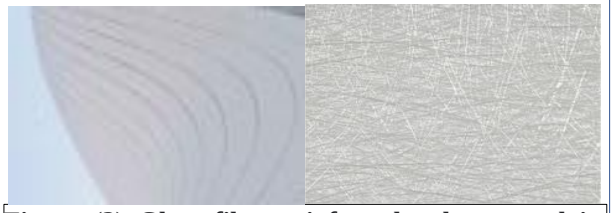


Figure (2) Glass fiber reinforced polymer and its applications [26]

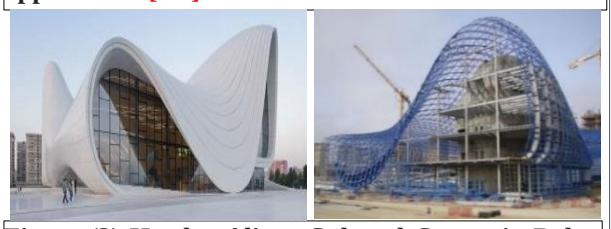


Figure (3) Heydar Aliyev Cultural Center in Baku, Zaha Hadid) [26]

3. Carbon Nanotubes:

The discovery of carbon nanotubes in 1991 is more critical due to their symmetrical structure and broad characteristics in industrial and scientific uses [16]. Carbon tubes Figure (5), and the tube wall may be single atoms, binary, or weight loads resistance ring light more, and they are called multi-wall (Nanotube) MWNT tubes, and the tube diameter ranges from less than one nanometer to 100 nanometers, and the most famous examples are carbon nanotubes ((Carbon Nanotubes). One of its most important characteristics is the enormous hardness that exceeds the hardness of (steel) (30-100) times, although the carbon density of these tubes is less than that of steel six times [4].

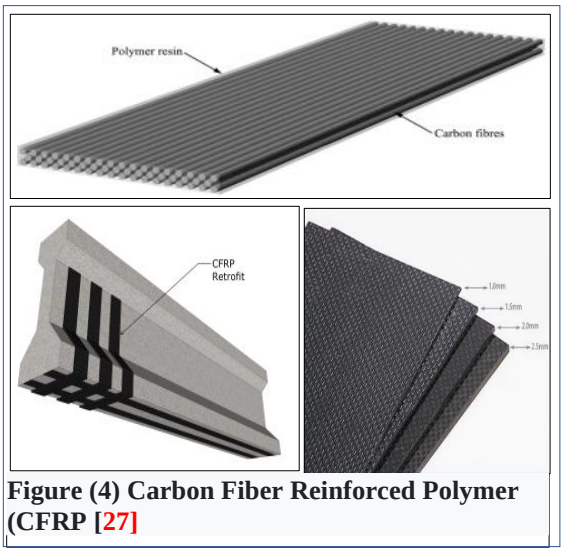


Figure (4) Carbon Fiber Reinforced Polymer (CFRP [27]

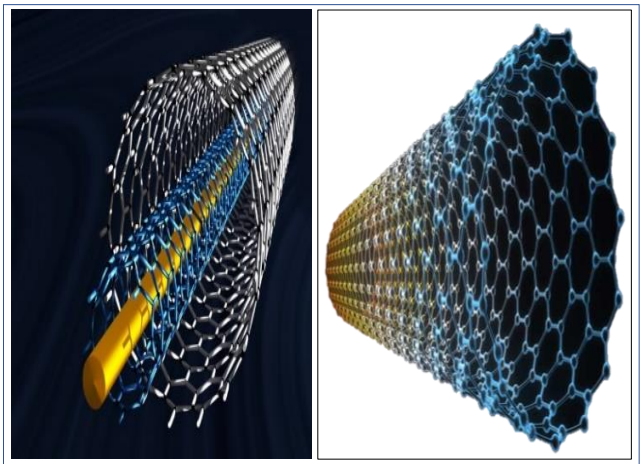


Figure (5) Different types of carbon-nanotubes-on-the-basis-of-chirality [28]

3. Objectives of Nano Architecture: [2]

- Improving environmental and economic performance, obtaining a self-cleaning building, and Table 2 shows the classification of the impact of some nanomaterials on the properties of materials and improving performance in buildings
- Increasing human comfort within the interior spaces by reaching the optimum temperatures by rationalizing energy consumption.

- Maintaining the integrity of the ecosystem by reducing carbon dioxide emissions.
- Obtaining a building that controls temperature and humidity according to climatic conditions.
- Obtaining a building that is light in weight, more robust and durable, resists cracks and cracks, monitors work and damages, and works on self-repair.

Table 2. the classification of the impact of nanomaterials on the properties of materials in buildings [1]

Classification of the effect of some nanomaterials on the properties of materials and improving performance in buildings		
nanomaterial	places of use	Characteristics (their effect on building elements)
titanium dioxide	The different roofs of the building (exposed to solar radiation).	Self-cleaning breaks down carbonic and organic compounds into hydrocarbons, which are environmentally friendly, anti-ultraviolet, anti-bacterial, and anti-fungal.
carbon nanotubes	Structural and non-structural elements	Increase the mechanical resistance of various elements
silica nano	Structural and non-structural elements	We are increasing the mechanical resistance of various elements and improving the plasticity, flexibility, and shrinkage of concrete and cement.
nano aluminum	Structural and non-structural elements	Increase wear resistance and rust resistance
carbon fiber nanotube	Structural elements (concrete), non-structural elements	Concrete self-treatment of deep and superficial cracks and microbial cracks.

4. Applications of Nanomaterials in Architecture:

The study of the behavior of materials at the nanoscale Enables building makers to develop new materials with unique properties and helps reduce the environmental impacts of cement and concrete mix production, as well as reducing the volume of carbon dioxide emissions in the building materials industry, as well as in waste recycling systems. And its environmental importance, which is part of the modern global trends, which aim to save on electricity consumption and energy used in cooling, lighting, and water heating, which reduces harmful carbon emissions, maintains the integrity of the ecosystem, and thus Extends the life of the building [11] And additives for materials used in construction such as “silica, alumina, titanium dioxide, shale metals, and carbon tubes, and they are used in “coatings, nanocomposites, additives for concrete and cement mixtures, and building adhesives,” producing building glass coatings and self-concrete mixtures. Which is characterized by its thin shape, high transparency, increased protection, and reduced maintenance costs, as well as thermal insulation materials, such as “aerogel” Figure (6), shows nano-ceramic films for thermal insulation of glass, a solid transparent gel material with a very lightweight, made of silica and carbon. It is described as a material with high thermal resistance.

The ad helps protect the house from fire. There are also nano-ceramic films for glass thermal insulation [20].

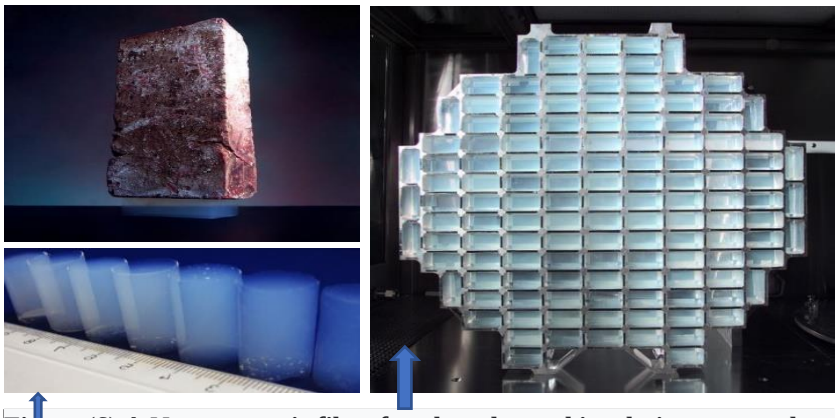


Figure (6) A Nano-ceramic films for glass thermal insulation - aerogel material [28]

4.1. Benefits Of Applying Nanotechnologies in The Construction Field:

Most of the world's countries have recently moved towards the use of nanotechnology in the field of construction by replacing traditional building materials with "modern building materials that are less expensive, smarter and environmentally friendly," which leads to the use of nanomaterials and their impact on architecture, which works to give people comfort through a building. Clean, healthy, low costs, then control the temperature and humidity of the spaces according to climatic conditions, resistance to high temperatures and harmful radiation, and also reduce emissions from carbon dioxide and neighboring buildings, fire protection, and the ability to self-clean through self-cleaning glass, Then you can clean the surfaces automatically and automatically and take advantage of them to protect the surfaces and walls from the adhesion of dust and pollutants, and to maintain the stability of color shades, and to resist ultraviolet rays, moisture and fog from the glass and thermally insulate the building, and it also has the ability to reduce maintenance by treating any cracks and cracks early, and repair it by itself directly and automatically, and makes it lighter in weight, more robust and durable and resistant to cracks, cracks and corrosion, [6] and reducing the proportion of what is known as sediment, or "calcification rash", and thus the building adapts to changing climatic conditions, as well as improving the properties of those materials With additions of nanotechnology materials to raise the efficiency of buildings and improve their quality so that those buildings are environmentally friendly.

Nanotechnology has also opened a new world for the employment of new materials and capabilities in construction, which led to the use of the best natural resources: high, low costs, long lifespan, and reduced need for maintenance [19].

The development of structural and non-structural materials and the coatings used impacted the external formation of buildings, which significantly moved the introduction of the new architecture. Table (3) shows nano materials Accor nanomaterials classification and how Their use in architecture shows the extent to which these materials affect the development of their performance and change the external formation of buildings, to access unconventional buildings.

Nanomaterials have sliding technology from several elements, and nanotechnology is used on a large scale to improve building materials as follows in construction materials, which are as follows:

Table 3. Classification of nanotechnology uses [1]

Type of uses of nanotechnology	nanomaterials	finishing materials	construction materials	
		glass uses	nanotechnology cement	
		Processed aluminum nanotechnology	nano iron	
			Nano-treated wood	
	Uses of nanotechnology in architecture	New structural materials - new finishing materials - coatings		
		Self-cleaning (lotus effect-photo stimulation), easy to clean, anti-bacterial, anti-graffiti, anti-fog, anti-reflective		
		Insulation Materials	Energy saving	sustainable energy
		Thermal insulation (vacuum insulation boards, aerogels, nanogels, thin films, PCMS) (Phase change material)		
		Building exterior design and energy saving		

Nano additives were also used in terms of their places of use and the techniques affecting the construction materials and their properties that made them an interactive material with climatic factors and then their impact on the external shape to give a distinctive and unique aesthetic appearance. With improved or entirely new characteristics [25]. Nanotechnology p provided many materials used in the construction and finishing of buildings that helped in developing their performance and contributed to achieving the required level from an aesthetic point of view and interacting with weather factors to make the building environmentally friendly.

Table 4. Characteristics of Structural Materials Applied to Nano [14]

Characteristics of applicable structural materials for nano					
Its characteristics (the face of benefit)	**places of use**	**Feature type**	**Technique used**	**Applicable nanomaterials**	
Physical properties - treat and reduce microbial cracks. Tio2: self-cleaning - self-treatment - which increases mechanical resistance.	external	self-treatment	Nano granules are added in different proportions when mixing.	Nanocomposites of Tio2	**concrete**
Pressure resistance reaches 88.91 nano/mm2 when using ratios 2% - (NS) 10%, (NS) for fracture resistance is added to 2% nano-silica without other additives (Al2o3) and increases the resistance to water permeability (NS) and works to improve flexibility – limit from dissecting calcium in the water and preventing water penetration into the concrete.	external	Resistance	Condensed silica fume-tri-nano aluminum oxide	Nano silica (NS) Condensed silica fume-tri-nano aluminum oxide	

Rust and corrosion resistance	external	anti-corrosion	Coating granules are added when manufacturing.	Nano-copper Nano-silver	Iron
The operating period of more than 100 years Low emissions and savings in concrete reinforcement from 20%:50% less than ordinary reinforcing steel - and reduces labor costs to 60% and less crowding (accumulation) of reinforcing steel.	Nano copper, nanosheets	Mechanical, physical, and chemical resistance	Rust-resistant 5 times more corrosion-resistant without protective coating (relative to conventional iron) Increased tensile strength.	the Nano technique (MMFX2)	
Self-cleaning uses a super water-repellent property that prevents leaching and water penetration into the wood's internal components. Wood does not rot - maintenance costs are reduced.	external	Self-cleaning (water repellent)	Coating - Thin Film	Self-cleaning lotus effect	the wood

4.2. Uses Of Nanomaterials Technology in Finishing Materials:

Nanotechnology has allowed architects to choose materials with alternative uses of nano for traditional textiles and to exploit those uses in buildings with different activities. Table 5 shows the characteristics of non-structural materials or finishing materials applied to nano [14].

Table 5. Characteristics of non-structural materials (finishing materials) applied to nano [1]

Properties of non-structural materials (finishing materials) applied to nano.					
material	Its characteristics (the face of benefit)	places to use	Feature type	Technique used	Applicable nanomaterial
the glass	-Physical properties that help self-cleaning by self-stimulation - Anti-bacterial- and anti-fungal - Anti-UV - Superior ability to repel water - Anti-fog. - Reducing pollutants and decomposing material residues without ultraviolet rays and reducing recurring maintenance costs.	external	Self-cleaning	Coating granules are added when manufacturing.	Tio2
Outer shell	- Easy to clean and wear -resistant. Preserve the shape of buildings, reduce maintenance costs, prevent graffiti, and reduce the use of chemicals harmful to the environment.	external	Anti-paint paint	Thin film coating	Different material

5. The Role of Nanotechnology Applications in Architecture:

Nanotechnology is the technology that was the result of rapid scientific development so that it became possible to modify the properties of the material by developing or changing its molecules themselves, and as a result, obtaining a technology that preserves the environment known it's as (Green Nanotechnology), which is represented by the merging of nanotechnology with environmental design, which It had two main goals: -

- Producing technology that is not harmful to humans or the environment.

- The second goal is to develop the traditional materials currently used to become materials that are not harmful to humans or the environment.

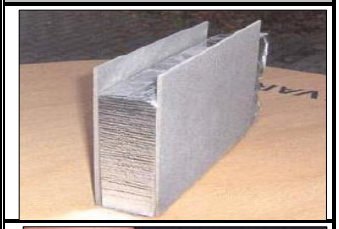
The application of these two goals is taken advantage of by the emergence of environmental materials produced by nanotechnology, known as (Carbon Nanotechnology), and the use and analysis of these materials to find out how much they save energy or how much they prevent carbon oxide emissions, through which the amount of carbon emissions number can be reached. It is equal to zero using this technology in the field of architecture.

5.1. Foundations And Determinants of The Application of Nanotechnology To The General Shape And Development Of Building Performance.

5.1.1. Functional Criteria:

Nanomaterials affect the Nanomaterials of spaces to achieve the needs at the required level of human comfort inside the vacuum (glass - paintings - insulation materials). Table 6 presents the characteristics and specifications of nanomaterial in isolation that helped these materials achieve thermal comfort. Reducing the temperature inside the vacuum and using glass treated with nanotechnology, the reflection of ultraviolet rays and the entry of visible inside the vac m by a large percentage to provide the appropriate natural lighting inside the space and reduce artificial lighting and thus all of this leads to energy savings as well.

Table 6. Characteristics and Specifications of Nano Materials in Insulation [1]

Insulation type	Features and specifications	Sample
Vacuum Insulation Panels (VIPs)	The thermal conductivity coefficient at 25 degrees is (0.0035 W/m2 Kelvin) W/m2 Kelvin. The thickness of the panels (35:8 mm). Density (240-280 kg/m3). It provides 10% of the total area of the building due to its low thickness. -Operating time from (30:30 years).	
Nano Gel) Aerogel	Reduced thermal conductivity: a “U-Value” of up to (0.28 W/m2 Kelvin) watts per square meter Kelvin. Acoustic insulation reduces transmitted noise. Low weight (80:60 kg/m3) UV resistance. -Natural light transmittance to 75%. Water and moisture repellent – high-temperature resistance.	
Thin-Film Insulation	It transmitted visible light at 61% Blocks 97% of infrared rays Blocks 99% of UV rays Reduces the temperature of the window to the interior space by 2-3 degrees compared to traditional materials	

The process of designing buildings is carried out in a manner that respects the surrounding environment with materials with modern technologies (nanotechnology) that do not affect the environment. Nanomaterials have affected creativity in the design of external facades. The outward appearance of buildings with the architectural formation and aesthetic values and new and modern models have been created, which led to the innovation and creativity of designers and how to choose the appropriate materials that benefit the building to meet the needs [10].

5.1.3. Economic Criteria (cost):

The goal is to reach designs with a distinctive and unique aesthetic appearance through the selection of materials with modern and new technologies with unique characteristics that change the architectural composition and interact with the surrounding environment and changing climatic factors. This is to achieve the required level of needs, according to the economic assessment of buildings applied to nanotechnology materials affecting the construction sector. A reduction in maintenance costs will be achieved by self-cleaning through the application of nanotechnology in buildings to provide the necessary energy and reduce the cost of buildings when they are operational. Table 7 shows examples of the classification of building international projects and the uses of nanotechnology materials in each.

Table 7. Examples of classification and uses of nanotechnology materials in each building [23]

Classification of nanotechnology for materials used in some international projects			
(Technology Type)	Uses	The building's name	Location
Self-cleaning (lotus effect)	coatings	Ara Pacis Museum	Rome, Italy
Self-cleaning "TIO2" (photocatalysis)	coatings	Muhammad Ali Center	United States of America
Easy to clean (ETC)	coatings	modern classic	Shanghai, China
Anti-Bacterial	coatings	Patient rooms in a Berlin hospital	Berlin Germany
Anti-graffiti	coatings	New Ulm Center	Ulm, Germany
vacuum insulation panels	Insulating materials	Center (residential, commercial) multi-activities	Munich, Germany
environmental materials	firefighting	Deutsche Post	Bonn, Germany

5.1.4. Energy Saving:

Energy is one of the essential foundations that must be considered in evaluating energy-intensive public buildings. Nanotechnology has provided energy-saving materials in external facades by applying nanotechnology to glass to be environmentally friendly, interact with climatic factors, and gain energy that benefits buildings and those around them. Thermal comfort can be achieved through nanotechnology materials by controlling their properties, such as the time impediment to the passage of heat from the outside to the inside and the density of nanomaterials' role in raising the efficiency of the material that affects the external interfaces and thus works on thermal comfort within the spaces [2].

5.1.5. Firefighting:

Fire resistance is one of the basics that must be considered when designing buildings. Nanomaterials have nanomaterial cited buildings become environmentally friendly with fire resistance, as nanomaterials techniques have been applied in many materials, the most important of which are (glass, aluminum, and wood), which affected the extent of fire resistance in buildings for periods of fire from inside the building [12].

5.1.6. Extending The Life of The Building (reducing maintenance - self-cleaning):

Nanotechnology resulted in materials with unique properties that are entirely different from traditional materials and shows a statement of the materials that were developed using nanotechnology and used in architectural buildings, which added a lot to architecture to reach buildings with modern technologies that interact with themselves on the over the period

specified for the buildings and thus lead to the prolongation of the life span of the buildings through the application of nanomaterials that treat cracks and cracks by self and maintaining the colors of the facades for long periods, taking into account taking the sites on which the building is built into consideration to interact with the changing climatic factors, to reduce the process of permanent maintenance of the buildings. The use of nanotechnology materials to achieve this in the building structures (concrete – ironwood) and thus dealt with damage to the building from rust and corrosion, as well as the materials applied in the finishing of the external facades (glass - aluminum) that help self-cleaning and thus reduce maintenance during the life The default of the building, and since the matter is related to the type of material, method of construction, weather condition, nature of the use of the building and other factors, and thus works to extend the life span of the buildings.

- The application of nanotechnology in architecture had many benefits, such as achieving the functional and aesthetic aspects of buildings, achieving energy consumption rationalization and conservation - cleaning buildings by themselves - building fire resistance - prolonging the lifespan of buildings, which had a good impact on buildings in terms of function, performance, operation, configuration, and the internal and surrounding environment of the building.
- The use of nanotechnology materials has the most significant impact in reducing the total cost of buildings as well as reducing the cost of maintenance and finding architectural solutions in building and construction, as it achieves for architect's unique and distinctive designs with a particular aesthetic appearance. Resisting environmental factors efficiently and with the required quality, helping preserve raw materials and their resources, and the ability to meet needs.
- Nanotechnology has helped solve some energy-related problems in architecture and construction by using nanomaterials in the exterior facades of buildings to obtain buildings with new architectural formations that are energy-saving, high-performance, low-cost, have an extended life, and reduce the need for maintenance.
- The application of nanotechnology led to the emergence of intelligent architecture in building performance, operation, and maintenance.
- Nanotechnology in the field of construction and construction has led to the emergence of paint systems with unique properties that reduce the accumulation and adhesion of dust and contaminants on the exterior surfaces of buildings and act as an anti-moisture, heat, oxidation, cracking of ultraviolet rays and constant change in shades of colors. Using paints with a lower cost and higher quality than other paints that do not consider environmental specifications and conditions prolongs the life of buildings and roofs.
- Nanotechnology provided materials that helped the architect to think and harmonize the selection of materials in buildings to balance the exterior with the surrounding environment. It also presented distinctive engineering thought directly related to nanotechnologies through materials that affected the exterior appearance of buildings—improving the efficiency of structures by applying nanotechnology materials in the external facades of buildings and determining the extent of the impact of their uses on architecture.

7. Recommendations:

- Through what has been presented and based on the results that have been reached about the role of nanomaterials technology in buildings to improve their efficiency accordingly, the research recommends the following:
- Increasing awareness and advertising of nanotechnology at the media level and publishing houses by posting in specialized scientific and architectural journals, architectural research and studies, and holding conferences and symposia that discuss the thesis of buildings applied to nanotechnology. It is necessary to encourage businesspeople to participate in the spending on nanotechnology research and allocate art of the financial resources to carry out the architectural and scientific research required to obtain outstanding results.
- Forming an integrated research team covering all disciplines related to nanotechnology in architecture to carry out a series of specialized research and studies and make integrated studies of environmental, economical, maintenance and operation aspects to derive new materials that contribute to solving building problems in terms of cost and energy consumption.
- The state must adopt the development of scientific research and the application of the nanotechnology approach and its study in the early stages of university education. He presented curricula for nanotechnology and its uses in architecture to find solutions to building problems (exchange of the latest and most prominent research and projects with global and Arab benefits of nanotechnology).
- Institutes specialized in building research and science prepare a code specialized in nanotechnology materials.
- The architectural designer needs to pay attention to the selection of nanomaterials used in the external facades and the places of their application to give distinctive formations and make unconventional facades, with the work of raising awareness at the level of architects about modern technologies in general and nanotechnology.

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