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NANO MATERIALS AS A MECHANISM FOR ACHIEVING CONTEXTUALISM IN ARCHITECTURE

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ABSTRACT

Contextuality is one of the concepts that emerged in the post-modern era and became associated with it as a design strategy. Its purpose is to generate context as a relationship between elements drawn from memory and stored (heritage). Context has both physical and intellectual dimensions in architecture, serving as the language of intellectual and material dialogue between the building and its surroundings. Among its principles are harmony and suitability with the environment, whether through the general form, the materials used in construction and decoration, or through the underlying architectural concept and its alignment with the region's customs and traditions. The absence of context leads to an architectural identity crisis and consequently results in randomness. This is why the research problem revolves around the lack of conceptual clarity regarding the possibility of achieving context in local architecture through the use of nanomaterials to create contemporary architecture. The research aims to elucidate the knowledge about nanomaterials and their potential in achieving contextualism through two direct (as a primary material) and indirect (as a secondary material enabling traditional materials) approaches. Additionally, it examines the environmental context brought about by nanomaterials (harmony with the environment). This is based on the assumption that nanomaterials can be used to enable traditional materials to achieve architectural context for the city. The research employs an analytical and deductive methodology to elucidate knowledge about nanomaterials and their manifestations in architectural production. It derives their influential role in shaping the architectural output by interpreting a set of their properties and characteristics and analyzing a group of buildings where nanomaterials were used. The research concludes that nanomaterials have a direct impact on the final appearance in terms of color, texture, and, hence, the architect must thoroughly study the materials and select the most suitable ones for the region to achieve contextualism.

KEYWORDS

Contextuality, Technology, Nanotechnology, Nanomaterials.

1. INTRODUCTION

Context is one of the concepts that emerged in post-modern architectural discourse, as an attempt to establish relationships between a building and its surroundings at multiple levels, aiming to create an interconnected urban environment. This context is subject to transformation due to internal and external forces that influence its formal characteristics (Al-Hankawi, 2009). Context emerged during the postmodern period from the desire to solve problems related to harmony with the historical environment, and the placement of new buildings within a historical context. Therefore, context became important in the relationships between the architectural element within the urban fabric and its immediate surroundings. This development laid a common ground for architectural design and urban design, by bridging the gap between these two different basic scales, to bring them closer together (Çizgen, 2012).

It is well known that achieving context is done on several levels (formal, social, and intellectual), and that materials play a major role in achieving that. Therefore, the purpose of this research is to clarify the role of materials in general, and nanomaterials in particular, in achieving context for contemporary local architecture. It also addresses the important and direct impact of materials in the correct use of them, and the exploitation of the available potential in them to produce contemporary forms that are suitable for the surrounding environment in all aspects. Recently, we have seen the use of new materials in the construction of buildings, which have moved away from the context in their environment, due to the lack of consideration of their compatibility with the surroundings. The goal of these buildings is only to produce new contemporary forms, by avoiding the use of traditional materials because they cannot produce the desired shape. Therefore, the question arises: Can context and the preservation of the contextuality of forms and neighborhoods be achieved using nanomaterials and their role in the potential of traditional materials?

2. RESEARCH METHODOLOGY

The study relied primarily in its first part on building a knowledge base for the content of the context and its relationship with the surroundings and its impact on materials, moving later to the concept of nanotechnology and the classification of nanomaterials and their potential. As for its second part, it reviewed using the analytical method global models in which the technology of nanomaterials was applied to identify the extent of its impact on the external form, context, and then the environmental performance of the building.

3. THE FIRST AXIS

3.1. Contextualism

The linguistic and architectural literature has described the concept of contextuality in multiple ways. The linguistic definition of contextuality, as stated in the Oxford English Dictionary, refers to "the action or mode of weaving together the fabric," pointing to the emergence of contextuality as a process that aims to generate context as relationships between the parts within a given text (Safo, 2011). Some architectural literature has shown that context is the relationships between the parts of the fabric, which was considered by post-modern architects as the targeted aspect in design, in order to deliver different messages to society on the one hand and create integration between architecture and the city on the other hand (Bognar, 1985). However, Al-Balori proposed a definition of contextuality in which she pointed out that contextuality is one of the applied intellectual orientations in the methods of advanced urban design theories, which translates the context into the art of weaving the urban scene in all that is understood from its multidimensional ties, and in which constants and variables of varying importance and locations move (Al-Baluri, 1997). This is an indication of the relationship between contextuality and the designer's intellectual positions on the one hand, and the mechanism for achieving it on the other hand.

From the above, it is clear that contextuality emerges as a deliberate design strategy for the designer based on the derivation of the context as a dialogue between the product and its environment, relying on selected references that are woven according to specific mechanisms in order to reach a holistic system that carries an identity with a unified contextual impression.

3.2. The importance of context

Contextuality refers to the final result of generating elements by bringing them together with events and circumstances, to be the background, environment, or framework for those events and circumstances. The importance of contextuality emerges when it has the ability to express its contents explicitly, and include them within a unified unit so that each of its elements is an integral part of it, thus forming the key to understanding any knowledge associated with any part of its parts (Çizgen, 2012). In architecture, the circumstances of forming the contextual event represent all the social, political, cultural, and economic conditions under which the physical environment was formed (Architects Design Partnership, 2007). The architecture of that event must be compatible with the surrounding areas, and it must be in a continuous response to them, and continue to indicate a single continuous scene (Burden, 2001).

Therefore, the environment must be dealt with in a way that is within the framework of contextual thinking, by focusing on making the design of the new environment added represent a point that connects between the old design and the future. In this way, the context is the center of ideas in everything related to the built environment, which creates the connection between buildings and their surroundings, and helps to generate ideas that help to solve future problems, in addition to forming an aesthetic environment as a result of coordination between the components. It is impossible for the visual enjoyment of individuals to be limited to a single building, unless it belongs to the appropriate environment for it, which forms a homogeneous and cohesive image with it.

3.3. Context and use of materials

Matter is an essential element in architectural work. It is used in its natural state or prepared according to specific qualities, which may partially change its natural appearance, which clearly affects the formative properties of the architectural product. The physical entity of any thing is determined by two elements: matter and form. The form is the embodiment that matter takes in nature, while matter is the means of feeling the thing. The nature of the material used in the construction of buildings in general imposes on the architect its structural formations and expressive language. Building materials - which are the basis of construction - appear when used either in their natural appearance or in an industrial appearance, resulting from the method of preparing them for use in construction. Therefore, it may have different geometric properties, whether in terms of size, density, or resistance, which determines certain uses for it based on its characteristics and the associated suggestive meanings (Marghani, 2013).

The control of building materials on the shape means that each material has its own specific properties that allow it to be formed in multiple images. Therefore, we find that the shapes of buildings are largely influenced by the type of material used, which partially affects the shape that the building appears in nature.

The façade of any building is the final product of the harmony and coordination of the architectural blocks and elements that enclose the functional spaces. The shape gains more ability to arouse wonder and admiration as it reveals a new value of aesthetic value, which in turn reflects many functional, structural, and architectural values. The design of a building façade is the result of the designer's interaction with a set of overlapping determinants (formative / environmental / functional / economic / cultural), and those determinants are translated through the façade elements, which range from recessed and protruding, openings and molded, in addition to elements of a decorative nature, with the use of the texture and color properties of the façade elements. When the designer tries to subject the elements of the façade to the values of architectural formation, his choice of elements, materials, and colors is based on their formative capabilities (Yahya, 1990). Despite the multiplicity of factors affecting the architectural formation of façades, which all combine to produce the final formula for architectural formation, the proportions of their impact differ when they interact with each other. However, there are two essential factors that play an active role in the formation process, namely building materials and the techniques used to deal with these materials. Through the material and the technique of its use, we obtain a variety of formations, depending on the difference in the environment and the type of building material available in it (Al-Ghazali, 2005).

To obtain the best formative results for the use of a material, it is necessary to study its natural, chemical, and mechanical properties. It is also necessary to study its formative possibilities in order to know its suitability for use. For example, there are materials that are suitable for use in internal spaces, and there are other materials that are suitable for use outdoors, due to their ability to withstand different weather conditions. There is no doubt that contemporary construction materials have played an important role in the life of man, and have contributed to the adaptation of his life and environmental conditions. This is due to the individual's desire to develop this life in a permanent and renewed way to create a comfortable and attractive atmosphere. Many construction materials have contributed to this, which architects have shaped, forming models of the utmost precision and creativity, which expressed the system of revolutionary development in the world of construction materials used in architectural design (Al-Sharif, 2017).

3.4. The relationship between construction materials, architecture and context

The relationship between building materials and architecture remained a simple and straightforward one until the Industrial Revolution. Materials were chosen either for their availability or for their aesthetic appeal. Locally available stone was often the primary building material for walls and foundations, due to its availability and durability. High-quality marble was used as cladding or as an exterior finish to cover the bare stone walls. Therefore, it can be said that the choice of building materials by architects before the 19th century was based on both function and form (Al-Sharif, 2017). The role of building materials changed dramatically with the progress of the Industrial Revolution. Instead of relying on experience and practice, architects began to use materials that were engineered and organized. We can say that the history of contemporary architecture can be classified according to the building materials that were used. From the beginning of the 19th century, with the widespread use of steel structures, which led to the creation of long-lasting and tall buildings, materials have transformed from being just a means of construction to a way of working and thinking, giving the architect broader capabilities and greater constructional possibilities. The position of modernity towards context is not a position that aspires to enhance, but rather it has established a strict position that aims to use the context in its own way (Addington, 2005).

The strict functionalist style of modernity means that ease of use and comfort are obtained through a scientific point of view, which appeared at that time represented by technology and industrialization. In this way, the building isolates itself from the surrounding environment, rejects traditional architecture, and establishes a completely new architectural language, opening up to the interior with large spaces, and establishing more transparency, through transparent exterior surfaces. Therefore, the developments in the technological field had a positive impact on spaces and their relationship with their context (Thomas, 2009).

4. THE SECOND AXIS

4.1. Technology

Technology is defined as: the method of production, or the sum of technical or scientific knowledge, related to the production of goods and services, including the production of tools, the generation of energy, the extraction of raw materials, and means of transportation. The concept of technology may overlap with the definitions of technique, industry, machinery, art, or work. It may also be associated with a productive field, such as space technology or construction technology (Ahlqvist, 2003).

4.2. Traditional materials

Traditional materials are those that are locally available. They are classified into several subcategories based on their identity, similarity of properties, and applications in various fields. Their types vary from country to country depending on the geographical location and the availability of their raw materials. Some examples of traditional materials include: stone, wood, brick, concrete, and iron (Al-Ghazali, 2005).

4.3. Nano concept

The term "nano" is derived from the Greek word "nanos," which means "dwarf." It is a metric unit of measurement that is extremely small, equal to one billionth of a meter, or ten times the atomic unit of measurement known as the angstrom. It is too small to be seen with the naked eye, but can be seen with an electron microscope. This unit is used to express the dimensions of the diameters and scales of atoms, molecules, composite materials, and microscopic particles such as bacteria and viruses (Leydecker, 2008).

4.4. Nano technology

It is a technology that controls the structures and properties of matter at the atomic and molecular level, and is concerned with building things (materials and tools) at the atomic and molecular level, to obtain great benefits. Its idea is based on rearranging the atoms that make up the materials, as the more the atomic arrangement of the material changes, the more the output changes significantly. In other words, products made of atoms are manufactured, and the properties of these products depend on how these atoms are arranged (Abdul Jalil, 2013).

4.5. Nanomaterials

It is an important field of nanotechnology, based on the approach of materials science related to nanotechnology. This field is concerned with the study of materials and morphological features at the nanoscale, especially those that have special features arising from their nanoscale dimensions. The "nanoscale" is typically defined as less than (one tenth) of a micrometer in at least one dimension, although this term is sometimes also used for materials smaller than one micrometer. (Changing the properties of the material while maintaining the shape) (Tschegg, 2010).

4.6. Characteristics of nanomaterials and the possibility of architecture.

4.6.1. Interactive

Interactive architecture represented a distinct branch of architecture, where both objects and space have the ability to meet the changing social and environmental needs of the inhabitants. This architecture, with the help of nanotechnology, was able to use a set of interactive elements. Although the experiments on these multifunctional membranes are currently limited to research projects, they have amazing potential for application on larger scales. The future may hold the possibility of architects using nanotechnology to create complex systems that make architecture closer to living organisms (Jaskiewics, 2008).

4.6.2. Growth and recycling

The idea of growth in future architecture was built on the simulation of genetic material in nature, by manufacturing something similar to seeds in the biological world, which contain the appropriate instructions for creating architecture that responds to its environment, and by using the development in computer science and nanotechnology (Chammah, 2011).

4.6.3. Response

The possibility of producing new materials through biomimicry research will have a profound impact on technological processes in the coming decades. Nanotechnology also offers architecture the possibility of creating responsive architecture, which will allow for better design variations that meet the needs of the user, and allows for the customization of nanoarchitectural space, which gives users more flexibility in determining their options according to their desires. Nanotechnology affects architecture through the materials it provides, at four levels related to weight, shape, molecular composition, and behavior (Fahmy, 2010).

4.6.4. Self-regulation

One of the most important distinguishing characteristics of biological systems is their ability to self-organize at the molecular level, resulting in patterns that respond to a complex series of complexities in shape, which respond to environmental conditions, such as the spiral formations of crustaceans. As well as the living wall that makes up the wood in living trees, which have been mimicked using nanotechnology, to produce self-organizing cellulose nanomaterials, similar in shape to beehives (Tschegg, 2010). The idea of self-organization has been transferred to future architecture, in terms of thinking about self-organizing and self-constructing architecture, using nanotechnology, which makes its future potential promising. The reflection of this on architecture through the thinking of self-generating architecture, (which considers architecture from a purely material side), regardless of the ethical and social aspects, is something that requires pause and attention, and contradicts the need for the unification of the two sides of thought and matter in architecture.

4.6.5. Self-Repair

The function of biological self-repair is closely related to the function of growth or self-replication, as it includes the various phenomena related to returning damaged living matter to its normal state. Nanotechnology provides the possibility of making materials capable of performing appropriate self-repair functions, in order to restore damaged parts caused by environmental conditions. The self-healing process in wood tissues was inspired to prepare a lightweight cellulose air gel by imitating the cellular structure of wood, consisting of composite polymers and silica, to provide nanoscale materials capable of growing and self-healing. To be used later in environmentally friendly buildings (Tschegg, 2010).

4.6.6. Learning

The predictive capabilities of biological systems are closely related to the ability of these systems to learn. While some of these capabilities are innate, others are achieved through interaction with the local environment, and may include an inductive approach, where general conclusions are drawn from observations of natural events. Smart materials also exhibit these capabilities through the embedded sensing and actuation devices, in order to respond better to external stimuli, by reassembling previous effects that include sensory data and data processing (Murrani, 2005).

4.6.7. Internal stability

Biological systems are exposed to constantly changing external conditions, and are typically characterized by continuous changes in their internal composition. These systems remain in a stable physiological state by carrying out coordinated responses that balance with these constantly changing environmental conditions. Smart materials can mimic these capabilities by performing innovative functions that allow them to automatically change their behavior in response to different environmental conditions (Brookes, 2005).

4.6.8. Response to temperature change

Smart materials of the thermostrictive type respond to the surrounding conditions by changing their shape and dimensions when the temperature changes (Ritter, 2007).

4.7. Nanomaterials and Architectural Form

Nanotechnology and nanomaterials have had a significant impact on the production of new architectural forms, through the integration of nanotechnology applications that have produced architectural forms that were previously impossible to achieve. These forms include (Harba, 2017):

- Flexible, dynamic, and tall architectural forms.
- Self-dynamic or externally controlled architectural forms.
- Biological and futuristic architectural forms that mimic both nature and humans.

The use of nanotechnology in architecture will make it regularly variable in response to the interaction of the building's components with its users. This dynamic environment will be mostly organic in its ability to respond to changes, and therefore architects must learn how to design for change. Additionally, the possibilities offered by 21st century technology allow designers to develop forms with great imagination, for futuristic architectural landmarks and futuristic architectural ideas, which cannot be achieved without this technology and the materials it produces.

4.8. Nano-Architecture

Architecture is like a living organism that grows and develops over time. With the advent of nanotechnology, architects began to try to understand this technology and exploit its capabilities to build architecture that interacts with the human senses. The integration of nanotechnology with architecture has given architects a wide range of freedoms and opened a door to architects seeking to innovate and overcome architectural problems through two main ways. These are:

Architectural materials design (nanomaterials): This is a term that refers to the ability of architects to enter into molecules, and control the shape of materials that provide a huge amount of building materials, to deal with them and control their properties to produce nanomaterials, in addition to the possibility of integrating the load-bearing structure of the building with the external and internal walls. This affects the decisions of architects and their design choices, and also gives new horizons for implementers to achieve everything that was impossible) (Fouad, 2012).

Nano devices and tools: Nanotechnology in architecture provides new Nano devices that can be an integral part of building elements, and work to transform the building to be an interface that has the ability to sense the surrounding environment, and output data on both sides, (responds between the internal spaces and external conditions), in addition to simulating living systems, producing designs that interact better with human senses (Ibid, p.57).

5. THE THIRD AXIS

5.1. Practical examples of the use of nanomaterials.

5.1.1. Heydar Aliyev Cultural Center Project / Baku, the capital of Azerbaijan, by designer Zaha Hadid.

The project is a curved block, implemented with the help of nanomaterials, which enabled the architect to achieve the desired concept, which is to create an architecture that is compatible with the surrounding environment and expresses the history of the region.

A special concrete reinforced with nano-fibers was used, which helped to create flowing shapes and reduced the thickness of the concrete required to cover the structure. In addition, glass fiber-reinforced plastic was used, coated with nano-materials that prevent staining, providing the desired color, gloss, and texture, as well as technical specifications for protection from ultraviolet rays, non-writable, and at the same time slip-resistant, to show the final distinctive shape of the building.

We conclude that the project, with its curved shape, was implemented with the help of nanomaterials, which helped the architect to achieve his desired concept and create an architecture that is compatible with the surrounding environment and expresses the distinguished architectural concept.

5.1.2. The Eden Project in the Eastern Amazon / England / Britain by Nicholas Grimshaw and Partners.

A huge industrial environmental complex. It contains eight domes, each of which simulates a specific ecological environment, containing a variety of plant species from different parts of the world. The locations of the bubbles were selected according to solar modeling (Solar Modeling), which is an advanced technology that shows the areas where crops will benefit from direct or indirect solar radiation. The project uses several sustainable strategies, such as using a rainwater collection system and wind turbines to generate electricity. The domes are made of ETFE, a high-strength plastic material. Three layers of it can be stacked, welded at the edges, and then inflated to size. Units can be made seven times larger than those made of glass, even though they weigh 8% of the weight of double-glazed glass panels.

We conclude that nanomaterials (ETFE) have enabled the project to achieve its concept, which is based on the creation of transparent domes that allow the penetration of sunlight, and are large enough to allow the cultivation of the largest number of plants, in addition to achieving harmony with the surrounding environment, which enhances the environmental context.

5.1.3. The Italian Pavilion Building at Expo 2010 - Shanghai - China, by architect Giampaolo Ambrigi.

The pavilion is a rectangular building with a square base of 60*60 meters and a height of 18 meters. The design looks like a huge gray square block with closed boundaries. The pavilion includes a hall, two restaurants, a gift shop, a library, offices, halls, temporary exhibition areas, and an internal courtyard. The pavilion was built using nanomaterials, represented by transparent light-emitting concrete, as a main building material with a transparency ranging between 20-80%, covering a total area equivalent to about 40% of the architectural structure. It also used low-emission energy-saving glass, self-cleaning, and stainless steel walls.

The envelope technology allows the transmission of the visual effects of light and images, without compromising the properties of the blocks. The transparency effect is more visible from the outside, especially at night. The external shape of the building has a dynamic and self-effecting dynamism throughout the day.

6. RESULTS AND RECOMMENDATIONS

1. There are several interpretations of context, on several levels, which may be intellectual, formal, or environmental, depending on time and place.
2. Context is not a constraint, but a tool for producing new forms, through dialogue with the surroundings, continuous communication with history, and harmony with the environment using nanotechnology.
3. The lack of knowledge of materials and their neglect as local materials, or because of their inability to create new forms, has led to the absence of formal context and harmony with the surroundings in urban areas, especially in developing countries.
4. One of the most important features of nanomaterials is continuous change, adaptation to external conditions, and rapid response. Therefore, they are the most suitable for use to

achieve environmental harmony with the surroundings (achieving context at the environmental level).

5. It is possible to use traditional materials in the construction of contemporary architecture (free forms), but after being enabled by nanomaterials. Nanomaterials are either used directly as a primary material to achieve context (as mentioned above), or indirectly, by using them as a secondary material that enables traditional materials to create new forms. Thus, there is no reason or obstacle to not using traditional materials.

6. It is necessary to understand the local architectural vocabulary and its elements from local styles, to enable understanding of the model of indigenous design principles and forms, and how to activate them in contemporary projects through contextual stylistic expressions.

7. Through transforming the basic properties of matter, nanotechnology will be able to change the way we build, and the acquisition of these features by materials helps to develop construction.

8. New areas of construction require cooperation between architects and materials scientists to solve specific design requirements using nanomaterials.

9. The importance of cooperation between multiple technological fields has emerged in the potential of contemporary and future architecture, such as the relationship between the virtual and real worlds, and providing the building with technology that senses the internal and external environment, and responds to it with the help of nanomaterials and sensors.

10. Nanotechnology represents the means that allowed contemporary designers to transcend known architectural forms, and push the boundaries of contemporary architectural design, to develop forms with great imagination for the landmarks of future architecture, which cannot be achieved without this technology, and what it produces of nanomaterials that provided the ability to create new functions for architecture that were not possible before, such as movement, response, change, and interaction, where nanotechnology relies on the interaction and coordination with other sciences.

11. Modern technological developments have had an impact on the expansion of the size and spread of building materials, and the diversity of available alternatives for use in architecture. They have allowed the use of new building materials, in addition to improving the properties of traditional building materials, and changing the nature of their use.

12. Contemporary construction materials are characterized by their ability to meet the needs of designers and consumers at the same time. Due to their diversity and properties that satisfy everyone, whether from the functional, aesthetic, or economic point of view.

13. The problem with modern construction materials lies in the random and unconsidered use by the consumer, who is tempted by the apparent form of the material, without taking into account the context with the surroundings.

14. The architect must make the construction decision according to the materials and technology available, taking into account the other surrounding conditions, which meet the required specifications and spatial relationships. He must also develop the closest to achieve the goals.

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