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# Smart Building Technology as an Approach for Sustainable Restoration and Preservation of Heritage Buildings

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**ABSTRACT:**The research addresses the definition of the concept of heritage, which carries many advantages that can be linked to the technology revolution, the presentation of the classification of heritage buildings, the knowledge of the general concept of sustainable development and the achievement of targeted development, the use of scientific progress in investing environmental resources and solving their problems and the presentation of the concept of sustainable conservation.

Also showcase smart technology materials and technologies for efficiency by introducing new technologies in the field of restoration of heritage buildings. Then to learn about the concept of technology with a view to upgrading the performance of buildings, The classification of modern chemicals into materials used in the cleaning phase - materials used in the strengthening phase - materials used in the protection phase, A presentation of some technologies used in the preservation of heritage buildings and the introduction of modern technology at all stages of the restoration process in order to improve and develop the work at each stage. Nanotechnology has proven its efficiency in preserving where this technology enables to extend the life of the building and reduce the required voltage and maintain and reduce energy consumption. Nanometres substances have achieved the highest required results compared to the use of conventional chemicals.

**KEYWORDS:** Sustainability of heritage buildings, sustainable conservation, restoration, nanotechnology, modern processing materials, modern technologies.

## I. INTRODUCTION

Heritage buildings are exposed to many negative impacts resulting from unconscious behaviours of the inhabitants of these areas and the use of new and inappropriate building materials that distort these buildings so that there is a new environment with a different identity that is not commensurate with the environment of these areas and the preservation of heritage architectural monuments requires the reduction of these effects and the qualification of heritage buildings to respond to the events of the times.

## II. THE MAIN OBJECTIVE

The main objective of the research is to determine the role of modern building technology in dealing with heritage buildings and to identify the mechanism, methods and advanced techniques for protecting and preserving heritage buildings by rehabilitating these buildings and facilitating their management process and using modern technology to sustain them without compromising their heritage value.

The research also aims to identify inexpensive technology tools that support the preservation of heritage buildings commensurate with the economic crises of conservation and restoration projects

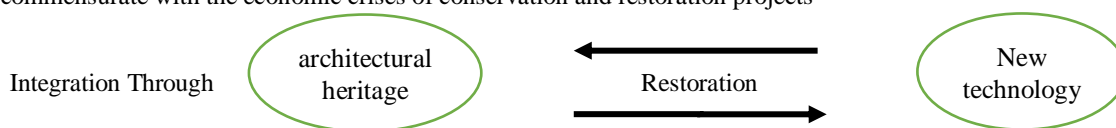


Fig. 1. Integration of

heritage and technology through restoration  
Source: Researcher, 2023

### III. THE RESEARCH PROBLEM

The problem of research arose due to the misuse of the majority of heritage buildings as a result of the development and the imposition of modern developments, which led to the neglect of these buildings, the threat of their demise, as well as the loss of identity of heritage buildings. The research problem is that there is no methodology for dealing with heritage buildings and their sustainability using modern means of technology and access to advanced technology suited to the environment framework and import of what is suitable for nature.

### IV. METHODOLOGY

The study was based on three main themes:

- 1- **Theoretical framework:** Includes the study of concepts that relate to the sustainability of heritage buildings and the importance of heritage buildings and sustainable conservation methods using smart building technology and the problems faced by these buildings.
- 2- **Analytical Framework:** Includes analytical study of some local and global models of heritage buildings and analysis of these experiments applied to heritage buildings and their environmental suitability and develop a set of recommendations that take into account the use of smart building technology that helps to sustainably preserve these heritage buildings..
- 3- **Application framework:** The study concludes with the presentation of the most important findings of the research of a list of modern building materials to deal with heritage buildings, which serves as a summary of the outline of the summary of what has been exposed and then translates those findings into a series of recommendations directed to a number of concerned authorities with a view to upgrading Egyptian architecture to the level at which we can compete and match the world level.

### V. THEORETICAL FRAMEWORK

**1- The concept of architectural heritage:** It is a tool that connects social and cultural phenomena to history. It bears the features of society, customs, traditions, religion and local cultures and carries the pros that can be associated with the technology revolution.<sup>1</sup> Heritage buildings are defined as "any building or facility characterized by a historical, symbolic, architectural, artistic, urban or social value" and carry civilizational attributes of society containing a set of heritage vocabulary under the title of the Law on the Protection of Antiquities where we find architectural values.<sup>2</sup>

**2- The general concept of sustainable development:** One of the most important definitions of sustainable development is the definition issued by the World Commission for Development and the Environment in 1987 at the Brundtland Conference, which defined sustainable development as "development capable of meeting the needs of the current world population without harming the ability of future generations to meet their needs." The conference touched on two basic issues: needs Human Needs: It is the priority, especially the needs of the poor, and it ranges from basic needs to sub-needs.<sup>3</sup>

**3- Achieving the goals of sustainable development and using smart methods in the restoration and preservation of heritage buildings:** The use of smart methods in heritage buildings ensures the continuity of these buildings and the achievement of the overall sustainable development goals. International charters have defined the relationship between urban heritage and sustainability thinking through a general premise that heritage is a driving force for sustainability. The use of smart technology in restoration preserves the environment and reduces energy consumption. These points are sustainable development criteria to achieve sustainable conservation.<sup>4</sup>

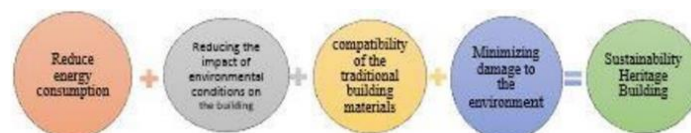


Fig. 2. Shows how positive sustainability can be in heritage buildings  
Source: Hossam Hasan Elbrombaly, February 2016

<sup>1</sup> - Tamer Mohamed Ragaa Al-Hubaishy, "Management of Maintenance and Restoration Projects," Master Thesis, Department of Architectural Engineering, Faculty of Engineering, Shubra, Benha University, (2021).

<sup>2</sup> - Rania Ismail Ahmed Ahmed, "Modern Restoration Technology is a Mechanism for the Life of Heritage Buildings," a master's thesis, Faculty of Engineering, Cairo University, 2006.

<sup>3</sup> - Ahmed Awad, Gomaa Awad, "Urban Sustainability in Areas of Historical Value," Master's thesis, Faculty of Engineering, Shubra, Benha University, 2007.

<sup>4</sup> - Hossam Hasan Elbrombaly, "High Tech. Solution of Using Nano Materials in Conservation The Heritage Buildings " Effat University, Jeddah, Saudi Arabia, February 2016.

**4- Smart technology materials and techniques in the field of restoring heritage buildings:** Nanotechnology opens a new world of advanced materials more efficient and capable of developing itself, giving new possibilities in the area of restoration and treatment of heritage buildings and working to increase and improve the performance of the building and remove pollution from the surrounding environment.<sup>5</sup>

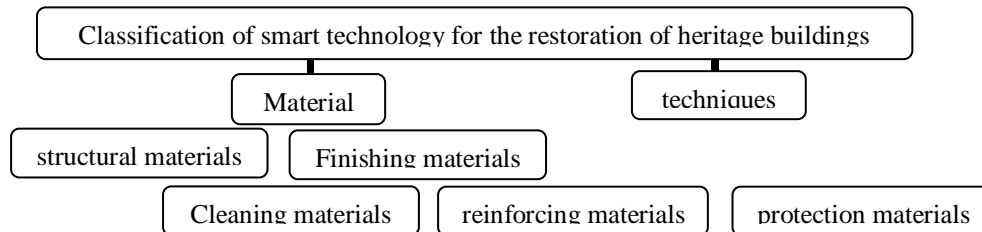


Fig. 3. Classification of smart technology for the restoration of heritage buildings  
Source: Researcher, 2023

- **Modern materials used in the cleaning phase:**<sup>6</sup>

- A- **Desalin C:** It is a cleaning material used to remove stains from the surfaces of stones and concrete surfaces and is applied by rinsing the surface of the material and showing the results within two minutes. Protective clothing must be worn when using this material and tested for part of the surface.
- B- **Desalin AM:** It is a paint used to clean and prevent mold and the growth of bacteria on external and internal surfaces and prevent black spots resulting from fungi and effectively protect stone exterior surfaces and is applied by brush without dilution and after 24 hours rubbing by brush and using this material every 6 months.
- C- **CNF.COOH carbon fiber:** Material used to clean marble surfaces and placed in Ultra-Sonic ultrasonic pathway for homogeneous product.
- D- **Titanium dioxide, TiO<sub>2</sub>:** To gain the material surfaces self-cleaning property and are applied as transparent layers on the material surfaces and depend on photo stimulation.<sup>7</sup>
- E- **Laser technology:** Laser technology is used as a manual cleaning method and does not affect the roofs of heritage buildings

- **Modern materials used in the strengthening stage:**

- A- **Calcium hydroxide (CaOH<sub>2</sub>):** Used to strengthen and isolate stones, separate and restore paint to the building's heritage walls and characterized by leaving no white deposits after removing them from surfaces. Used to strengthen and isolate stones, separate and restore paint to the building's heritage walls and characterized by leaving no white deposits after removing them from the processing surfaces.
- B- **Magnesium hydroxide:** Used with nano calcium hydroxide to strengthen dolomite limestone.
- C- **Nano silica:** Used to support stones as they repel water and resist dust and oil.
- D- **Primal AC33:** It is a water solution of the paraloid and is found in the form of a white emulsion that tends to glaucoma similar to the Venaville emulsion and dilutes water to the required ratio of operation and chemically installs the same components of the paraloid, which is used as a reinforcing material added to it by weight ammonium hydroxide.<sup>8</sup>

- **Modern materials used in the protection stage:**<sup>9</sup>

- A- **Halo Stone material:** It is used to protect limestone, marble and natural stones from stains and moisture and can be applied by paint or spraying and gives a better result by using an HVLP spray gun and its effect in 8 days. Physical properties: transparent color - environmentally friendly - gives a glossy surface - has no smell.
- B- **Serfamix C:** It is a material used for cement mortar that strengthens its interconnectedness and is used for internal and external interfaces and is applied by placing it directly on the cement mixture or placing it on a mortar already in the building using brush and the surface is dry and clean.

<sup>5</sup>- Rania Ismail Ahmed Ahmed, "Modern Restoration Technology is a Mechanism for the Life of Heritage Buildings," a master's thesis, Faculty of Engineering, Cairo University, 2006.

<sup>6</sup>-Abeer Ahmed Hassanein, "Using nanomaterials in preserving heritage buildings," a master's thesis, Faculty of Engineering, Ain Shams University, 2015.

<sup>7</sup>- Ahmed Abdulaziz HassaneinHajjaj, "An Experimental and Applied Study Using Nanometer Materials in the Treatment and Maintenance of Archaeological Building Materials, Applied to an Archaeological Building in Rosetta City," Ph.D. thesis, Cairo University, 2018.

<sup>8</sup>- Zainab Mahmoud Abd al-Rahman Muhammad al-Najjar, "Modern trends in the maintenance and restoration of residential buildings and facilities," Master Thesis, Faculty of Engineering, Cairo University, (2019).

Physical Properties: White milky liquid - has a slight smell - pH 10 - used as an additive to restoration mortar to improve operation and reduce cracks - reduces dust on surfaces - reduces water absorption by 70% - works for a long time - resistant to climatic factors.<sup>10</sup>

- C- Servapure C: A substance that is mixed with materials instead of water or applied directly to surfaces, so it works to expel water and prevent moisture, and 1/3 of the water used in mixing with the materials is replaced with a nanomaterial, as a result of which it repels water after 24 hours.

Physical properties: Milky white liquid – has a slight odor – pH 7.1 – used for natural and artificial stones – works as a water insulator – resists ultraviolet rays – is an environmentally friendly material – prevents the formation of fungus – prevents the formation of white spots.<sup>11</sup>

- D- Nano Zone Wood: It is a material that makes wood corrosive, easy to clean and ultraviolet resistant and is water permeability coating for wood.

Physical properties: protect wood and maintain its natural appearance - prevent moisture - ultraviolet radiation - resists termite attack - reduces the growth of organisms and fungi.

- E- Paraloid 72: Methyl polymer acrylate is characterized by its good light gates and retains solubility when exposed to weather conditions. It gets some oxidation after time. It does not change color and remains flexible, water and alcohol resistant and biological damage resistant.

It is used in iron surface paint and in wood reinforcement and can be mixed with some other materials to get new materials used in the surface paint of heritage buildings.

#### VI. THE ANALYTICAL FRAMEWORK



Study some examples Nano has been used in processing and comparing them in the materials used.

- Analytical study methodology: The analytical study is based on a working methodology that addresses objectives, approaches, criteria and factors for measuring success.
- Objectives of the analytical study: Analysis of the results of the previous study by analyzing the impact of modern nanomaterials and technological technologies on heritage buildings and achieving sustainable conservation through the use of these technologies and materials.
- Analytical study method: The study followed the descriptive and analytical methodologies to achieve the study's objectives by: 1- Setting criteria for sample selection for study 2- Data collection through authoritative books and references, scientific articles and published research.

Criteria for selecting analytical examples and studying evaluation points using nanomaterials and modern technologies to reach preservation: Analyze experiences both locally and globally for the use of technological processing materials whose use results in reaching the best results and then evaluate these experiences and demonstrate their success and evaluate this success through several factors:<sup>12</sup>

- 1- **Durability**: carrying capacity for loads (providing structural safety) and the building's ability to survive longer.
- 2- **Utility**: The restoration process achieves its purpose.
- 3- **Beauty**: the restoration achieves two compatibility elements with the building's materials and the restoration does not affect the beauty of the heritage building.
- 4- **Economy**: The economy element affects the restoration of buildings and selectable for the lowest cost.
- 5- **Compatibility and consistency**: Compatibility of materials with old building materials to achieve aesthetic element.
- 6- **Clarity**: to distinguish new material additions from old materials and a painting in the building.
- 7- **Safety**: safe and do not damage the building's restoration materials in the long term.
- 8- **The complementarity of this material with the heritage building**: measuring the equivalent of the material.
- 9- **Achievement of the goal as a result of the use of modern technology**: measuring the achievement of the goal.

Identification of the assessment points of the buildings with nanomaterials to reach the extent of achievement of the technology in the buildings. The degree of evaluation of each assessment point is determined by the use of specific codes for each criterion so that each symbol indicates the extent to which the building achieves each criterion by classifying it to levels of "achieve, not meet the evaluation criteria" as in the following table:

		<u>assessmentscales</u> : Achieve	not achieve
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<sup>10</sup> - Abdullah Ahmed Abdullah Hasaballah, "Applications of Nanotechnology (The Impact of Nanotechnology Applications on the Materials Used in the External Facades of Buildings)", Master Thesis, Department of Architectural Engineering, Faculty of Engineering, Cairo University, (2017).

<sup>11</sup> - Abeer Ahmed Hassanein, "Using nanomaterials in preserving heritage buildings," a master's thesis, Faculty of Engineering, Ain Shams University, 2015.

<sup>12</sup> - Rania Ismail Ahmed Ahmed, "Modern Restoration Technology is a Mechanism for the Life of Heritage Buildings," a master's thesis, Faculty of Engineering, Cairo University, 2006.

1- **All Saints Church Little Kimble:**<sup>13</sup>  
 - information about the heritage building:

Table.1. information about All Saints Church Little Kimble

All Saints Church Little Kimble	
The site	The Church is located in the Diocese of Oxford in Makombe, England, 5 miles 80 km south of .Ellesbury
Modern materials and technologies used	Nano hydroxide calcium suspended in alcohol
Project Description	The church and altar dish was built in the 12th century of limestone, and the windows of the northern wall were constructed before the mid-13th century. The walls of the dish were decorated with large drawings .from the early 14th century, one of England's most valuable paintings



Fig. 4.A picture showing the appearance of All Saints Church from the inside and outside

Source: [http://en.wikipedia.org/wiki/Great\\_and\\_Little\\_Kimble](http://en.wikipedia.org/wiki/Great_and_Little_Kimble)

- Manifestations of the degradation of the heritage building:By examining the walls, the following was found: The appearance of cracks in the walls indicates the separation of layers between stone and plaster used - the impact of the presence of insects such as spiders and bats on the drawings that characterize stone walls in the church, resulting in the presence of small cracks with walls and the disappearance of a large part of those drawings - the appearance of a layer of salts on the walls.



Fig. 5.Picture showing small cracks and holes in the wall

Source: <http://www.sacred-destinations.com/england/little-kimble-church>

- Documentation and studies:Restoration work began in 1930, when the walls of the church were restored by waxing and was considered to be the best treatment, but over time this type of restoration was shown to have failed to cope with various factors of moisture and saltsIn 2010, a new measure of nanoscale hung with alcohol and the identification of the places to be injected was introduced:

- 1- Treatment of walls from moisture by drying them out by injecting various cracks with Industrial Methylated Spirits (IMS) which facilitates the process of penetrating nanomaterial into the wall.
- 2- Strengthen the lithographic walls by injecting precise cracks with calcium hydroxide into the nanoscale and injecting slowly to give an opportunity to alcohol used with nanomaterial (ethanol 25 E- or 50 (E - was used to evaporate to avoid a group of fog preferred during this operation on graphics).
- 3- Several days later, it was found that the areas injected with nanomaterial had performed the required function of strengthening the stone walls without leaving any external or eye-noticeable trace.

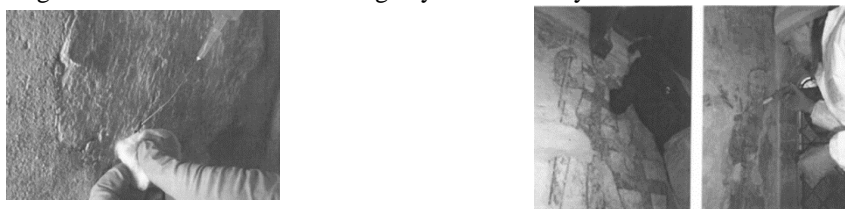


Fig.6.Using IMS material before injecting the Nano cracksFig.7.Injecting cracks with Nano material and supporting drawings on it

<sup>13</sup>- Abeer Ahmed Hassanein, "Using nanomaterials in preserving heritage buildings," a master's thesis, Faculty of Engineering, Ain Shams University, 2015.



Source:PaulD’Armada,Elizabeth Hirst ,”nano-lime for consolidation of plaster and stone “,journal of architecture conservation ,Montfort university ,London,2012 ,p.78

Table.2.Evaluation of the use of calcium hydroxide at the Nano scale

Evaluation of the use of calcium hydroxide at the Nano scale		
standard	Achieved / not achieved	aspects of achieving the standard
Durability	Achieve	Strengthen the limestone walls by injecting accurate cracks with calcium hydroxide into the nanometric
Utility	Achieve	The goal was to treat stone walls of nano moisture and showed successful results
Beauty	Achieve	Tackling cracks in stone walls has helped to retrieve the element of wall beauty
Economy	not achieve	Modern and high-cost technology
Compatibility	not achieve	The principle of compatibility between calcium hydroxide and stone walls has no different properties to .vary the shape and nature of each material
Clarity	not achieve	The use of calcium hydroxide and Industrial Methylated Spirits (IMS) is not visible. A plate must be placed showing the restoration (for scientific honesty)
Safety	Achieve	Implemented easily and does not pose a risk where they are not made using pressure or vibrations
Technology integration with the heritage building	Achieve	Technology integrates with heritage building to address moisture and cracks in stone walls
The extent to which the goal and objectives of sustainable preservation are achieved	Achieve	The goal of nanotechnology-based treatments has been achieved in preserving the church's stone walls and achieving sustainable conservation goals such as material recycling - innovation - site sustainability - increased durability and durability

Source: Researcher, 2023

Table.3.Points for evaluating the use of calcium hydroxide at the Nano scale

evaluation points	Compatibility with the building material		Reducing damage to the environment		Protection from environmental influences over time		Economy
	beauty	Compatibility	Clarity	Safety	Durability	utility	the cost
Evaluation metrics	Achieve	not achieve	not achieve	Achieve	Achieve	Achieve	not achieve
code	●	○	○	●	●	●	○

Source: Researcher, 2023

**VII. EXPERIMENTAL RESULTS**

**The previous studies for researchers in this field, through which the principles of scientific research are achieved, namely, the beginning of where the others finished, the use of many previous studies to benefit from them in this research.**

- Assessment of the efficiency of nanotechnology materials in restoring heritage buildings to achieve sustainable conservation:

Nanomaterials have been able to demonstrate their efficiency in addressing the environmental pollution problem faced by most Arab countries, as they are highly ecologically efficient and make them the most suitable alternative to the internal and external environment of the building for conventional restoration materials.

Nanotechnology has also demonstrated its efficiency in preserving the environment of various contaminants and reducing the risk to the surrounding environment of the building. Work has been done to compare the conventional materials used to preserve the heritage buildings and the methylation of the materials in the nanoscale available for use from their efficiency in the calendar and treatment of previous stones and timber materials:



Table.4.Comparison of traditional materials with nanomaterials in terms of the result that appears on the building material

Subject Name	The technology made of the material, its specifications and advantages	Scope of use in the heritage building (restoration and maintenance work)	use in modern architecture	traditional way	The extent to which the goal has been achieved	The method using nanomaterials	The extent to which sustainable conservation goals are achieved	How to use the material			Places of use of the material in the building				Impact on the environment
								injection	paint	sticky	walls	Floors	ceiling	Elevations	
<b>carbon nano fibers</b>	It is strong and lightweight, and has properties that make it ideal for use in various industrial and commercial applications.	Removing resins and black soot - used in cleaning various surfaces - in strengthening structural elements and reducing marbling in concrete	They can be used to produce products that are stronger and lighter than those made from conventional materials.	Use of organic solvents	Difficulty controlling these solvents during the cleaning process, which exposes the effect to damage - Bloating - Damage to the original bonding material	The use of carbon nanofibers (CNF-COOH) dissolved in Tween20.	Removing layers of soot and calcification from surfaces High cost - Nanomaterials gave a better result in removing soot than enzymes			√			√		It has no effect as no environmental or health risks have been found yet.
<b>Nano Silica</b>	Silica nanoparticles: water repellent - resist dust and oils - make the surface self-cleaning - unaffected by sunlight and invisible - resistant to corrosion and temperature change	Cleaning the archaeological building material - used in the treatment of sand and limestone from dust	The concrete mixture gains more strength, less permeability, and moisture insulation	Use of gelatin materials	The presence of gelatinous residues that are difficult to remove from the surface of the material	Addition of silica nanoparticles to Megaprotech (2)	Removing the gelatinous network easily using a magnet - It isolates the surface and makes it self-cleaning - Reduces the rate of heat transfer	√			√		√		Cause a change in the color of the surface - Affect the respiratory system in case of prolonged inhalation - Irritating to the eyes, skin and mucous membranes - It has no effect on the environment
<b>Nano zinc Oxide</b>	Nano-Zinc granules: self-cleaning - colorless	Strengthening sandstones - used to make surfaces exposed to various weather factors self-cleaning	Use in coating the exterior cladding of industrial buildings	Use of Faker OH100	Reducing stone porosity and water absorption - resistance to mechanical stress	Adding zinc oxide nanoparticles to Faker OH100	Increased resistance to mechanical stresses		√		√			√	It has no effect as no environmental or health risks have been found yet.
<b>Titanium</b>	1- Surfashield G:	Use on windows	Use in concrete	_____	_____	Use of	It gives the building		√		√		√	√	It has no harm to





<b>Dioxide (TiO<sub>2</sub>)</b>	disintegration of organic substances on the surface - water helps remove dirt, purifies the air - energy conservation - antibacterial - prevents ultraviolet rays from penetrating walls - decomposes gases and volatile organic compounds	makes it self-cleaning, so it reduces the effort required for cleaning and maintenance. Use on wooden surfaces to resist bacteria and fungi	to make surfaces self-cleaning and water-repellent without the need for a moisture sealer			titanium dioxide on surfaces	material the ability to self-clean - purify the air – It is used on stone to combat bacteria and slow deterioration on stone surfaces – It is used on wood to combat mold.							human health – It helps to conserve energy by its ability to prevent the penetration of sunlight into the walls – Non-flammable – Its life span is long
<b>Nano Calcium Hydroxide</b>	Calcium hydroxide nano granules: resistant to salts and moisture – has high adhesion strength	Fine crack injection - Use in strengthening and isolating limestone and stone surfaces - Separating and re-adhering paint to walls - Treating wood from acidity	Use in the manufacture of building materials to become self-moisture resistant	Use a mortar consisting of lime and epoxy resin	Any weak parts on the surface must be removed because the epoxy needs a solid surface to complete the gluing process	Use of calcium hydroxide nanoparticles	Strengthening the surface and filling fine cracks - Isolating and protecting limestone surfaces - Re-adhesion of paint to walls	√			√			It has no effect as no environmental or health risks have been found yet.
<b>copper (Cu) or silver (Ag) Silver</b>	Nano silver granules: environmentally friendly - helps kill bacteria	Wood strengthening - use in cleaning graves and underground areas	Use in interior spaces of poorly ventilated spaces - use in painting interior claddings in hospitals	Using the Iregal method d	Wood discoloration - do not prevent wood shrinkage after drying - it takes a long time to apply	Addition of nanoparticles such as copper (Cu) or silver (Ag) to wood reinforcement materials	Giving wood the ability to repel water, self-clean and resist damage - Protect wood from ultraviolet rays - Giving wood the ability to resist fire		√		√	√		Environmentally friendly, as it sterilizes the surface within two minutes by killing more than 650 bacteria
<b>Magnesium hydroxide</b>	It is non-toxic, tasteless and odorless, with high hardness and high wear resistance.	Stone strengthening		Use of calcium hydroxide	Poor penetration into the stone - leaving a white deposit on the surface	The use of magnesium hydroxide nanoparticles	Increasing roof insulation from environmental factors	√			√		√	It has no effect as no environmental or health risks have been found yet.

Source: Researcher, 2023

**Through previous tables to study the sustainability of heritage buildings using chemicals in their traditional scale and nanoscale investigation, nanomaterials have been found to give the required efficiency to better sustainability of heritage buildings.**

#### VIII. CONCLUSION

Through the above, nanotechnology was able to prove its ability to preserve the environment and provide an element of sustainability for heritage buildings, by adding nanoparticles with some chemicals used in various restoration and maintenance operations, or using nanomaterials without additives.

The materials at the Nano scale have achieved the highest required results compared to the use of traditional chemicals without additives, which provided an opportunity for restorers to restore heritage buildings without worrying about the sustainability of the restored materials over time or the costs required for that, although the cost of nanomaterial's is higher than the cost of traditional chemicals. Its lack of use over time as a result of its lack of efficiency in restoring building materials and protecting them against various factors of damage ensures that there is no need for their repeated use, as happens with other traditional materials.

The research has come up with a set of results that explain the problems that lead to damage to heritage buildings, the way to deal with them, and the use of modern materials, technology and techniques. The results were as follows:

- In order to achieve a sustainable heritage, technological progress has produced methods and technologies that contribute to the application of sustainability principles with high efficiency and the development of materials, which in turn will enhance the development of new applications and products. Therefore, it is a highly efficient system that is compatible with the surrounding environment with minimal damage.
- The use of modern technology materials has a great economic return, although it is initially expensive, but it has many advantages that exceed its price, as it saves on building maintenance, is environmentally friendly, works to reduce harmful emissions, and saves on the consumption of electrical energy for buildings.
- The technology of using modern technological materials is nothing but raising the level of sustainability in buildings in a more efficient manner that is less harmful to the environment.
- Nanotechnology has an important impact on heritage buildings, improving durability, improving the performance of building materials and energy efficiency.
- Calcium hydroxide does not leave white deposits as it does in its natural scale, which gives better efficiency for the required result in the restoration process.
- Silica nanoparticles are considered one of the best materials for treating sandstone due to the presence of silica component within this type of stone. Magnesium nanoparticles are also considered the best materials for treating dolomitic stone.
- Titanium dioxide nano material has a superior ability to clean the air of bacteria inside the internal spaces with poor ventilation, so it can be used in the maintenance of these spaces to increase environmental efficiency.
- The materials used in the cleaning, strengthening and protection operations take a long time to prepare in addition to the additional cost due to the addition of other materials to these materials to give them the goals to be reached by applying them to building materials.
- Digital technologies have a tremendous impact on heritage buildings and cultural heritage, preserving and benefiting from it, and providing complete information to preserve the structure of the building through virtual models. green heritage.

#### IX. RECOMMENDATIONS

-Raising awareness of modern smart materials technology through curricula, seminars, workshops, conferences and educational lectures in the various governmental and educational sectors at all levels and on a regular basis.

- Urging the use of smart technological materials in the treatment of heritage buildings, prolonging the life of the heritage building and preserving it, saving in maintenance and reducing harmful emissions, despite its high cost, but its economic feasibility is much better than ordinary materials.
- Supporting specialized studies in the field of restoring heritage buildings with modern smart materials and giving specialized courses to workers in the field of restoring heritage buildings.
- That any heritage building be restored under the supervision of specialists in restoration and maintenance from the Supreme Council of Antiquities, even if the building is not owned by the building.
- Not to use any materials in the restoration and maintenance operations except after making sure that they are suitable for use without causing any damage in the long term.
- The small number of published researches on nanotechnology in the Arab world, which led to a lack of intellectual and cultural awareness of its importance and an increase in fears about it.
- Recently, Egyptian scientific theses related to nanotechnology and its ability to contribute to raising the level of conservation in Egypt were prepared, but they do not find sufficient welcome to appear and use their actual results in centers specialized in restoration and maintenance.
- Cooperate with Arab and international countries in the field of dealing with heritage buildings in order to obtain a specialized technological base and attract expertise in this field in order to support technological development and advance the movement of progress and creativity.
- Urging and encouraging companies and private parties to adopt projects for the restoration of heritage buildings with the technology of modern materials in order to open the way for the recognition of its advantages at all levels, touching them on the ground, and obtaining more efficiency and a better economic return.

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