Science Arena Publications
Specialty Journal of Architecture and Construction
Available online at www.sciarena.com
2016, Vol 2 (2): 105-114

Monuments Sustainable Restoration by Nano-Technology Methods

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Abstract: Restoration of architecture is a branch of architecture that is recreated so that based on the recognition and restoration of historic monuments and sites, leads in reconstruction of historical spaces in terms of body, structure and function. Today, restoration of historic buildings is not limited to limited areas or special architectural environments; but it is the way of implementing a general idea that can be extended in the community and among technical people. On the other hand, with the help of creativity, it will stimulate the scientific and practical development in the field of valuable monuments sustainability. On the other hand, scientific creativity and practical; help to stimulate valuable monuments in the area of sustainability. On the other hand any scientific and technological creative action requires sufficient attention to identity. Human development toward perfection has a fundamental impact on the quality of the development of conservation science. This platform should be provided by the cultural heritage organization in any nation. Today, in the field of nanotechnology, what seems in the first look is friendliness of this technology to the environment and attention to saving energy. The use of new technologies such as Nano-Technology in the construction and restoration of historic monuments can be considered among the effective factors in establishing functional features of architecture including providing secure sustainability of the country's cultural heritage. The aim of this study is to investigate the possibility of using nanotechnology in repair and restoration of quality of the materials in monuments. This is a cross-sectional study based on survey-analytical measures and field study is required. Hence by examining library resources in the field; the position of restoration and development of its important items in stabilization of monuments with the help of nanotechnology in this area is discussed. The results show that materials used in renovation and restoration of monuments can be effective based on theoretical back grounds.

Keywords: Nano-Materials, Restoration of Monuments, Architecture Body, Nano- Technologies, Sustainable Conservation

1. INTRODUCTION

Restoration is a ritual, continuous and conscious measure that is done to regenerate, prevent erosion and corrosion and prolong the life of building, complex or context. This includes a set of interventions that take different meanings in different conditions.

Our country has a long history that in addition to its cultural and artistic importance, it has a special economic importance and protection of these works is one of the major concerns of cultural heritage organization. One of the architectural requirements is to respond to the impressive needs of the society. So, the up-to-date architecture along with technology is considered one of the suitable solutions, because a smart environment can respond to a lot of needs of society that may have not been considered since the past. Its important point is the interaction with the surrounding environment in line with sustainable architecture. Nanotechnology has a strong role in this field in particular through the building materials. The main purpose of sustainable architecture is reduction of energy consumption and elimination of environmental pollution and interaction with environmental conditions (Ghazvinian, 2014). One of the principles of Iranian architecture is the use of local materials. This feature has the interaction of building with its environment

and compatibility with its surroundings and also it considers cost-effectiveness and the prevention from wastage of energy. With a glimpse, we can find that the observance of them is among the principles of sustainable architecture. In traditional buildings with passage of time, the local materials are recyclable, and this doesn't damage the environment, because materials are pure and chemical composition had no role in them.

The chemical composition will harm the environment because it is out of this cycle. For example, in many traditional buildings, brick was used as the main materials. Although, they are weaker than the rest of the materials in terms of efficiency, but in terms of health, organic materials are nowadays considered (ibid.). One of the applications of Nano in architecture is reduction of the consumption of raw materials, energy as well as reducing carbon dioxide emissions, conservation of natural resources, more dynamic economy and therefore more comfort (Haghpanah et al., 2013) and we can say that all of these are major steps in achieving sustainable design (Tannaziyan and Sarbangholi, 2012). The use of new technologies in the process of optimizing the materials used and the methods of restoration are very important in the field of protection of cultural and historical objects (Bagherpour et al., 2015). Nano-materials, structures that one of its dimension is beneath and their second dimension is sub-micrometer have a nano-structure (ibid). If one of the dimensions of an object or one of its components is on the nanometer scale, it is called Nano material (Edrisi, 2010).

Words	Description & Meaning
Regeneration	**Regeneration is a process which creates a new urban space while preserving the main features (physical and activity) of a new space.**
Rebuilding	**Rebuilding sometimes means reconstructing and spatial organization based on what has been traditionally (something that is obsolete today) and sometimes means creating traditions passable to the future.**
Remodeling	**This occurs as a result of urban restoration. In this area, it is usually tried to obtain a new model from the spatial organization, so that this new model will also offer new forms and leads to new activities and also raises another space. Remodeling considers correction and changes in the work.**
Reintegration	**The action is done during the process of re-activation and reintegration, in fact, it is done when a part or parts of the spatial organization is practically out of the spatial relationships and life cycle and the renewal of that part or parts and re-enabling and their reconfiguration to spatial organization is on the agenda.**
Preservation	**The word means protection, conservation and the refusal from danger and harm to the body or performance of the work and eventually leads to the adoption of appropriate measures to prevent possible risks. In this issue, regular monitoring and inspection, maintenance, repair, study of various structural changes and possible deformation and understanding the risks and damage caused by wear and erosion of space and building include important factors considered.**
Protection	**This word means creating suitable conditions to maintain continuous urban space. Protection could include measures such as developing a set of rules, attracting government support, identifying conservation areas and so on and it also includes restoration and repair measures.**
Consolidation	**Consolidation refers to a set of measures by which we witness the increase in security, robustness and sustainability of space, complex or building. The main purpose of this operation is raising the durability and integrity of the structure of spatial organization. In urban spatial scale, this is raised in consolidation of the spatial structure and in building scale, in consolidation of structures.**
Revitalization	**This term includes diverse and complementary set of measures done to restore life or revitalization of building or urban space. These actions can be done in the**

	physical - spatial organization and it removes or adds parts of the old physical-spatial organization, without any prejudicing to its overall body. The regeneration in these actions includes all economic, social, cultural and physical areas.

Nano and its role in protecting historical monuments:

Today, knowledge necessary for the conservation of a monument is not limited just to archeology and historical information and art semiotics of the work. Science has an essential role both in deep understanding of the components of a unique historical work and in comprehensive cleanup and repair and protection of these works. Today, nanotechnology that is a relatively young scientific branch, has a history of less than a century and helps protection science to meet the specific needs of this discipline (Attari, 2008).

History of using Nanotechnology in restoration

Nanotechnology is a title used for the first time by Dr. Eric Drexler in his book Engines of Creation in 1986 (Didari, et al., 2011). Nano-scale is close to the scale of atoms and molecules, so we can say that nanotechnology is a technology at levels of atoms, molecules and macromolecule in the range of 1 to 100 nanometers (Salimi, 2008)

Nanotechnology has recently some practical applications in the maintenance and restoration of cultural heritage in the world. Hydroxide and calcium carbonate nanoparticles have been used for maintenance of frescos such as painting of Maya in Mexico or artistic masterpieces of the 15th century in Italy. Nanoparticles are also used to restore old paper documents that the acid in ink has lost their cellulose fibers. Florence which is rich in valuable cultural resources is one of the best places for studies of conservation of these works. University of Florence, is considered after hurricane in 1966 that Colloid and Surface Science Research Centre as the first center with a scientific approach to the study cultural heritage degradation. Now colloid is the most advanced nanotechnology-based method developed for the restoration of wall paintings. These include methods for cleaning and removal of resins from wall and oil paintings, watercolor paintings consolidation and removing acid from the papers that are now used in different parts of the world. Application of nanotechnology-based processes for consolidation of wall paintings and paper de-acidification is an evidence of the huge potential of nanotechnology in the protection of cultural heritage.

History of using nanotechnology in restoration in Iran

For the first time in Iran Nanotechnology was used in the restoration of monuments in Isfahan province. Application of this technology includes protecting and restoring previous material of the structure, the use of tiles with durable antibacterial and self-cleaning paints, structural control, resuscitation and strengthening of structures and so on (Ghazvinian, 2014).

Maintenance of ancient monuments with Nano coatings

Antiquities and monuments are considered as obvious structures and heritage of each country. Therefore, it is necessary that these buildings to be well repaired and reconstructed at first step and to be permanently protected in the next stage. Nanotechnology created advanced coatings to protect surfaces of buildings and could permanently protect them from destruction by environmental factors and visitors.

Cloud Nano-coatings are dirt and water repellent and resistant to ink and paint to avoid writing memorabilia and destruction called anti-graffiti, and they can protect important historic buildings as well as commercial and administrative buildings with expensive facades.

German company Degussa has a product called Protective which is chemically combined with the minerals of ancient buildings and is resistant to bad weather conditions and scratch. This material which is also resistant to UV rays, don't allow paint and contaminants to stick to the surface of the building.

Consolidation of monuments with the help of nanoparticles of calcium hydroxide

Some artistic – historical works have been severely damaged over time with exposure to air pollution and various climatic conditions. The fragility of these works is such that restoration will be troubled in de-acidification and consolidation. So designing methods by compounding can accelerate the repair operations and has no long-term detrimental effects on the monuments, are very important.

Artistic – historical monuments are quite fragile to acid hydrolysis and oxidation processes caused by weather conditions. In the method using calcium hydroxide nanoparticles, three repair operations can be performed including de-acidification, antioxidant and consolidation during a stage, in a way that while reducing restoration time, it will have no adverse effect on monuments in long-term.

The use of calcium hydroxide nanoparticles allows spraying materials in the repair process. Spraying nanoparticles leads to lack of stain and wrinkles in paper of restoration due to the small size of nanoparticles and lack of density of minerals in the paper. High depth of penetration caused by nanoparticles absorption by the paper fibers cause high efficiency of the nanoparticles compared with larger particles.

Consolidation

By using the silver and carboxymethyl cellulose Nanocomposites of simultaneous on detoxification and consolidation, the Nano-composite has a significant influence on preventing attacks of most microorganisms to paper, Nano-composites also dramatically increases the tensile strength of papers that become like cotton due to severe attacks by microorganisms. According to researchers conducted, the Nano-composite has a positive impact on the fight against other harmful agents such as harmful ultraviolet rays and insects (S. Majzoob Hosseini, 2014).

Definition of nanotechnology

Nanotechnology is the capability to produce new materials, devices and systems with controlling at molecular and atomic levels and using properties appeared on the surface. This simple definition implies that nanotechnology is not a new field, but a new approach in all disciplines. Various applications are called for nanotechnology in various fields of food, medicine, medical diagnostics and biotechnology to electronics, computer, communications, transport, energy, environment, and materials, aerospace and national security. Wide range of applications in this field with its social, political and legal consequences raised this technology as a multidisciplinary and trans-sectional area.

Table 2: Some important historical events in the formation of Nano-technology and science (El- Maged, 2008)

Date	Important Events in the Nanotechnology Researches Field
1857	Michael Faraday discovered gold colloid solution
1905	Explanation of the behavior of colloidal solutions by Albert Einstein
1932	Creation of atomic layers as one molecule thick by Langmuir
1959	Feynman raised the idea of "too much space at low levels" for working with Nano-scale materials
1974	For the first time the term nanotechnology was uttered by Taniguchi
1981	IBM invented a device by which atoms can be moved individually.
1985	Discovering the new structure of carbon C60
1990	IBM demonstrated the ability to control the placement of atoms
1991	Discovery of carbon nanotubes
1993	Production of first high-quality quantum dots

1997	Production of first Nano-transistor
2000	Production of the first DNA engine
2001	Construction of a fuel cell in vitro model using nanotubes
2002	Anti-stain pants came on the market
2003	Production of laboratory samples of solar Nano-cells
2004	Research and development in the field of nanotechnology continues...

Nano-composites

Nanocomposites are materials that combine nanoparticles in the form of standard materials such as polymers. Polymer refers to a substance that is created by combination of similar materials and repetition of monotonous building blocks. With combination of nanoparticles, we can achieve certain characteristics, namely the mechanical strength, durability, and electrical and thermal conductivity can be changed as needed. The advantage of nanoparticles is that even adding a lot of this material increases the weight of the material as 0.5 to 5% that this amount is negligible. So far, few Nano composites have entered the stage of business, and most of them are still in the testing phase.

Nanocomposites containing nanoparticles such as filters, nanotubes and Nano- carbon and graphite fibers, are widely used in the plastics industry. The function of nanocomposite is the surface to volume ratio of very large particles, which makes their properties to be changed dramatically. This feature also will make the combination of nanoparticles with bulk materials different. So, the composite can often be improved with regard to its constituent elements.

Current applications of nanocomposite, nanocomposite plastics have different applications, for example thin film capacitors can be used in computer chips. The solid polymer electrolytes are used in a variety of batteries, car engines, fuel tanks and food packaging that the latter two have more use. If nanocomposites have reasonable performance cost ratio, can play a fundamental role in the automotive industry. Some tips in the use of nanocomposites in commercial form are as follows:

1. The development of materials with larger volumes at lower costs
2. Production of material at a lower cost and higher efficiency
3. Faster and less costly development of analytical methods
4. Control of rheology in polymer composites
5. Increased strength without increasing the volume
6. Prediction of modeling direction / current

Nano-composite materials based on polymers (polymer matrix) were first introduced in the 70s which have used Sol - gel technology for the publication of the mineral nanoparticles within the polymer matrix.

Types of nanocomposites can be classified as follows on the basis of their base material:

1. Polymer matrix Nanocomposites (PMNCs)

Most attention is focused on polymer nanocomposites. One of the reasons for developing polymer nanocomposites is its excellent mechanical, physical and chemical properties. Polymer nanocomposites generally have high strength, low weight, high thermal stability, high electrical conductivity and high

chemical resistance. Reinforcing polymers using organic and inorganic matter is very common. Unlike conventional amplifiers that are in micron scale, in nanocomposites amplifiers are nanometer size particles. By adding a small percentage of nanoparticles to a pure polymer, tensile strength, yield strength and Young's modulus will be increased significantly. For example, by adding only 0.04% of volume of mica (a type of silicate) with dimensions of 50 nm to Epoxy, the Young's modulus of the material will increase 58%.

2. Ceramic matrix Nanocomposites (CMNCs)

3. Metal matrix Nanocomposites (MMNCs)

Nano particles of cement

Adding nanoparticles which lead to formation of Nano-crystals will increase the compressive, tensile and shear strength (Golabchi, 2012). Cementitious adhesives that are created using Nano particles of cement, have less processing time and higher early compressive strength than ordinary cement (Lee SJ, 2005).

Nano-silica

In recent years, studies have focused on Nano silica particles, aiming to increase concrete strength more than ever before using this material. Experiments conducted on Nano-silica, have shown that these particles are not a problem for the environment, but also provide better results compared to micro silica (Florence Sanchez, 2010). Research has shown that adding Nano -silica more than micro-silica increases the resistance of concrete (Sobolev K. 2005). Nano-silica mixed with concrete in the long term maintains the health of workers, concrete and the environment. Nano- silica also can reduce the consumption of cement, improved concrete quality and increased its efficiency (Gaitero JJ, 2008) (Li H, Xiao H-g, Yuan J, Ou. J, 2004) (Sobolev K. 2005).

Iron oxide Nanoparticles

It is observed that the use of nanoparticles of iron oxide in the cement increases the compressive and flexural strength and also cause the ability of self-sensing capabilities in concrete (Li H, Xiao Hg, Yuan J, Ou J, 2004).

Nano-titanium dioxide

Photo-catalytic self-cleaning is one of the most important uses of nanotechnology in the construction industry. Natural and industrial pollutants such as NOx, carbon monoxide, VOCs and aldehydes and chloro-phenol resulting from autos and industrial wastewater will be decomposed using the photo-catalyzer and with the help of titanium dioxide nanoparticles very active catalyst (Murata Y, 1999). Researchers also have shown that the use of nanoparticles of titanium dioxide in addition to its self-cleaning property, increases hydration speed and decreases the setting time (Bittnar Z, 2009) and increases flexural and compressive strength of concrete as well (Li H, Zhang Mh, Ou Jp, 2006) (Li H, Zhang Mh, Ou Jp, 2007). One of the disadvantages of this method is reduced degradation performance over time (Lackhoff M, 2003).

Features and combinations of Nano silver

One of the most important properties of silver compounds is its antiseptic character. From 1884, silver nitrate solution is used 1% as eye bath. Silver compounds were extensively used in World War I for disinfection and

today these compounds are used in the treatment of severe burn injuries. Silver nanoparticles are produced and used in two main forms, including silver ions and metallic silver ore. The silver ion is a suspension in which silver particles are in the form of ions obtained from silver compounds in the carrier and its impact is possible through ion mechanism. The compound is mostly based on silver nitrate or silver chloride, which shows its effect in carrier suspension which is usually water. In the other case, nanoparticles exist in the form of metallic silver in carrier which is usually water or ethanol and act through catalytic mechanism. Of course, silver nanoparticles are also produced as powder which are prepared as suspension in carrier or consumed directly as an additive.

In fact, the Nano silver is particle manufacturing in nanometer-scale and remains in the same dimensions; however, metal nanoparticles tend to bind together to form larger units. Therefore, the compounds are required to prevent it and keep silver in the same dimensions and preserve the silver nanoparticles suspension. For this reason, adding Nano silver to a compound that changes the suspending agents can cause significant changes in the composition of Nano silver, in a way that even particles exist the Nano-mode and precipitate and the desired efficiency is not achieved. To investigate this issue, the interaction of 50 ml colloidal of silver nanoparticles with 20 ml acetone, under a ppm metal experiment with concentration of 4000 was conducted. Acetone was selected because of its widespread use in the processes of restoration. Adding acetone to colloidal of metal silver with a nonionic suspending agents caused the loss of transparency of the compound and creation of sediment in it that in the deposition through point tests by reagents, the silver was identified. This is a cause of the dissolution of suspending agent and existing silver from the Nano state. It should be noted that the features of Nano silver depend on silver particles' shape and dimensions and other compounds associate it to protect these features.

Applications of Nano-silver

The most important pests affecting the cultural and historical monuments can be classified in three general categories: bacteria, fungi, and insects. Activity of these pests in monuments requires several factors, including favorable environmental conditions, favorable material for nutrition and lack of toxicity of it.

In fact, the function of pesticide or preventive compounds is based on removing one of these factors. Silver nanoparticles in addition to the destructive effect on critical components of microorganisms, makes the material inappropriate due to nutrition and greatly hinder the activity of insects. Meanwhile, the dose of compounds' effect will be different in different cases. Of course, minimum ppm of inhabitation concentration for silver nanoparticles is about 10. Extensive studies have been done on the antibacterial effects of Nano silver that all emphasized the antibacterial properties of silver nanoparticles and its effective application in this regard.

The use of Nano silver in textiles, especially cellulosic fibers achieved very good results. Antifungal properties of Nano silver have also been confirmed in various studies. The composition on fiber causes the lack of damaging fungi and in this regard, preventive and protective effects of Nano silver to fungus Chaetomium globosum is very noticeable. This is considered as the most important soft-rot in the wood which badly damages cell secondary wall in wood. This type of decay is considered as the main reasons of destruction of wood discovered in Saqqara and Giza Egypt. The fungus enters irreparable damage to the organic survivors in marine and humid environments. The protective effects of (industrial) Nano silver against termites show the high capacity of this compound to deter termite attack. Although the best combination for the treatment is a mix of nanoparticles of silver and zinc, but Nano silver is considered as one of the best add-ons to the protective materials, meanwhile recognition of the influences in the compound and their interaction with material is of utmost importance. On the other hand, the carrier of particles should not cause fundamental or malicious changes in the object. For example, the interaction of water carriers and some of the materials used can cause problems in the care process. Of course some of these interactions have shown positive results. For

example, the results showed that the addition of Nano-silver colloid in water to acryloid dispersions in ethanol not only didn't result in the deposition of resin, but also enabled using B72 in the materials simultaneously. On the other hand, due to low concentrations of nanosilver, changes in color tone is not very noticeable, but the exact knowledge of these changes will be necessary before the use of Nano silver. It should be noted that monuments over time often tend to darkness and don't suffer not significant changes as a result of using Nano silver. Another issue in this field is the reversibility of the product. Ionic silver nanoparticles are stabilized by bonding and metallic silver nanoparticles by deposition in the matter. Even assuming stabilized material by physical involvement, its complete removal from the material structure without damaging it is unlikely, but the potential of re-treatment of the material will not be disappeared and breathing material also continues. As a result, no damage will be imposed to the originality of the work. In fact, although the use of these compounds in the field of protection and restoration of historical and cultural objects is at the beginning of their research, but its features represent the suitable properties for use in the field of protection. Of course, exact knowledge of its impact and changes over time is among the most important issues that need to be explained precisely.

Nano-Technology Applying in Architectural Heritage retrofit	**Weakness** (W1) Lack of financial support (W2) Lack of representatives in most provinces (W3) Little knowledge of the experts in this field	**Strength** (S1)Appropriate infrastructure for preservation and access to valuable heritage (S2) Employing young people in towns (S3)Employing experienced and specialist consultants
Threats (T1) Limitations in using nano technology in some towns (T2) Lack of trust of the organization towards foreign representatives (T3) Welcome of the cultural heritage towards traditional repair procedure	(Strategy based on W/T) (T3)/(W3) Educating the work extension and features of nano (T2)/(W3) Creating thought of usage and advantages of nano	(Strategy based on S/T) (S1)/(T1) True and on time publicity and explaining the facility (S3)/(T2) Stating the support and after sale services
Opportunities (O1) Growth of the nano technology usage culture (O2) Possibility of optimizing the preservation of historical buildings (O3) Saving in time (O4) Maximum protection of old Iranian culture	(Strategy based on W/O) (W1)/(O3) Optimal use of time and energy and decrease in cost (W3)/(O4) New ideas for preserving the historical works	(Strategy based on O/S) (O1)/(S1) Creating a successful example concerning the issue of repair (S2)/(O2) Increase in self-confidence of the young people and expert forces in this field and saving in the costs

Conclusion

Historical Monuments constitute the backing of any nations and are documents of their historical identity. Protection of these works, which are known as fundamental human rights, is essential. Historic monuments that over time have been influenced by different damages, influenced by factors such as air pollution, erosion, fires, industrial pollution, acid rain, have a polluted and eroded appearance and many of the motifs, images and plasters are buried under a layer of pollution with a thickness of history. If we have no solution to remove these contaminants, these buildings will be gradually destroyed. Paying special attention to new technologies in the field of nanotechnology could help us to repair and maintain them. Today, new technologies are promising more effective treatment and protection methods, but their use in the field of protection of monuments is related to creativity and knowledge of experts in the field. However, this unique technology is newly developed, but historically for centuries smart nanoparticles have been used in artistic objects. Today, science is able to detect the subtle use of nanoparticles in past. The use of this technology to strengthen and stabilize murals, paper acid-removing, strengthening paper, detoxification of cellulosic works are clear evidences of the huge potential of nanotechnology in the protection of cultural heritage.

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