# THE ROLE OF NANOTECHNOLOGY TO REALIZE HUMAN COMFORT IN INTERIOR SPACES

# دور تكنولوجيا النانو في تحقيق الراحه الانسانيه في الفراغات الداخلية

(1)**Prof. Dr.** Kassem S. El-Alfy (*Vice Dean for postgraduate studies & research, Irrigation Engineering and Hydraulics Department, Faculty of Engineering, Mansoura University)*

(2)**Prof. Dr.** Huda M. Azzam *(Professor Dr. and Head of Architecture Department, Faculty of Fine Art, Alexandria University)*

(3)**Dr.** Mona A. Elwazeer (*Lecturer of architecture department, Faculty of Engineering, Mansoura University)*

(4)**Architect.** Marwa M. Elbeialy (*Architect, Architecture department, Faculty of Engineering, Mansoura University)*

**ملخص:**

هذا البحث يلقي الضوء على التطور الملحوظ في الأونة الأخيرة من اكتشاف الجديد في مجال التكنولوجيا والذي أدى الى ظهور تكنولوجيا النانو والتي أصبحت ترتبط بحياتنا اليوميه وأصبح لها ارتباطا وثيقا بمجال العمارة مما أدى الى ظهور مسمى جديد يعرف ب "عمارة النانو" وهي تعتمد على تكنولوجيا النانو في تصنيع مواد جديده لها صفات خاصه تساهم في حماية الانسان والبيئه من التلوث وايجاد بيئه داخليه صحية تحقق الراحه الانسانية بمقاييسها وقيمها المثالية مثل تحقيق الراحه الحرارية بمقاييسها باستخدام مواد عازله للحراره ، وبمعنى آخر محاولة الوصول الى مباني صحية صديقة للانسان والبيئه عن طريق الاستفاده المثلى من تكنولوجيا النانو ومحاولة تجنب الآثار السلبية لها وأيضا محاولة وقف استنزاف الطاقه وايجاد طرق بديلة للحفاظ على الطاقة باستخدام مواد النانو .وبهذا يكون الوصول الى الهدف من تكنولوجيا النانو قد تحقق واصبح لدينا عمارة النانو التي تحقق الراحة الانسانية بكل مقاييسها . وقد تمت دراسة البحث من خلال ثلاثة جوانب وهي:- -الراحة الانسانية، -عمارة النانو، - تطبيقات على عمارة النانو.

## Abstract:

This research sheds light on the remarkable development in recent , as explore the new in technology which led to appearance Nanotechnology which become associated with our daily lives and become closely linked to the field of architecture which led to appearance of new name known as " Nonoarchitecture " depends on the Nanotechnology for manufacturing new materials with special qualities , this materials contribute to the protection of ( the humans & environment ) from pollution and to find healthy indoor environment to investigating human comfort with its ideal values & standards , Such as investigation of thermal comfort with its standards by using heat insulating materials , and in other words trying to access healthy buildings friendly to humans & environment by the optimization of Nanotechnology and trying to avoid its negative effects , also trying to stop the energy drain and find alternative ways to conserve energy by using nano materials , So the access to the target of nanotechnology has been done and now we have nano architecture which achieve human comfort by all of its standards . This research has been studied from three sides:-

- Human comfort. - Nanoarchitecture. - Applications on Nanoarchitecture

Accepted September 15, 2012

# 1. Introduction

People feel uncomfortable when they are too hot or too cold, or when the air is odorous and stale. Positive comfort conditions are those that do not distract by causing unpleasant sensations of temperature, drafts, humidity, or other aspects of the environment. Ideally, in a properly conditioned space, people should not be aware of equipment noise, heat, or air motion. The feeling of comfort "or, more accurately, discomfort" is based on a network of sense organs: the eyes, ears, nose, tactile sensors, heat sensors, and brain.[ 1]

Nanotechnology is an exciting area of scientific development which promises "more for less". It offers ways to create smaller, cheaper, lighter and faster devices that can do more and clever things, use less raw materials and consume less energy.
It represents a whole new method of manufacturing, which achieves control at the atomic scale. It is better described as a collection of technologies which are genuinely "disruptive" that is, they will render many existing technologies and processes obsolete and create entirely new types of products.[ 2]
Over the coming years and decades, nanotechnologies are set to make an enormous impact on manufacturing and service industries, on electronics, information technology, and on many other areas of life, from medicine to energy conservation.[ 2]
For the architecture profession, nanotechnology will greatly impact construction materials and their properties. Materials will behave in many different ways as we are able to more precisely control their properties at the nano-scale.
As new materials and construction methods emerge, the advent of everyday use of nanotechnology will definitely unleash the designer's imagination.[ 4]

# 2. Human Comfort:-

Human comfort is defined as the state of mind that expresses satisfaction with the surrounding environment. Factors that determine human comfort include: temperature on the surrounding environment, humidity of the air, air motion etc.[5]

Human factors are the most important components of Human Architecture besides the main approach of energy consumption and preservation. That factors are reflected by introduce comfort and healthy spaces, which suitable for human occupation both physical and psychological.

Building better is not only about avoiding problems, it should also be about creating positively pleasurable and healthy living places. Comfort is about the physical environment in its totality. The issues which are most obviously associated with comfort are:

- Temperature
- Humidity
- Noise
- Light
- Smell

The definition of 'the healthy built environment' incorporates both the urban environment outdoors and the indoor surroundings.[6]

# 3. Nanoarchitecture:-

1. Nanotechnology in General Science.

2. Nanoarchitecture.

### 3.1. Nanotechnology in General Science:-

Nanotechnology, shortened to "Nanotech", is the study of the control of matter on an atomic and molecular scale. Generally, nanotechnology deals with structures of the size 100 nanometers or smaller, and involves developing materials or devices within that size. Nanotechnology is very diverse, ranging from novel extensions of conventional device physics, to completely new approaches based upon molecular self-assembly, to developing new materials with dimensions on the nanoscale, even to speculation on whether we can directly control matter on the atomic scale. For example, if you take aluminum and cut it in half, it is still aluminum. But if you keep cutting aluminum in half until it has dimensions on the nano scale, it becomes unstable, becoming highly reactive. This is because the molecular structure was changed.[ 7]

#### 3.1.1. Air Pollution and Nanotechnology

There are two major ways in which nanotechnology is being used to reduce air pollution:

1- Catalysts, which are currently in use and constantly being improved upon; Catalysts can be used to enable a chemical reaction (which changes one type of molecule to another) at lower temperatures or make the reaction more effective. Nanotechnology can improve the performance and cost of catalysts used to transform vapors escaping from cars or industrial plants into harmless gases. That's because catalysts made from nanoparticles have a greater surface area to interact with the reacting chemicals than catalysts made from larger particles. The larger surface area allows more chemicals to interact with the catalyst simultaneously, which makes the catalyst more effective.

2- Nano-structured membranes, which are under development: -

Nanostructured membranes, on the other hand, are being developed to separate carbon dioxide from industrial plant exhaust streams. The plan is to create a method that can be implemented in any power plant without expensive retrofitting. [ 8]

### 3.1.2. Water Pollution and Nanotechnology:-

Nanotechnology is being used to develop solutions to three very different problems in water quality.
1- Removal of industrial water pollution, such as a cleaning solvent called TCE, from ground water. Nanoparticles can be used to convert the contaminating chemical through a chemical reaction to make it harmless. Studies have shown that this method can be used successfully to reach contaminates dispersed in underground ponds and at much lower cost than methods which require pumping the water out of the ground for treatment.

2- The removal of salt or metals from water. A deionization method using electrodes composed of nano-sized fibers shows promise for reducing the cost and energy requirements of turning salt water into drinking water.

3- The third problem concerns the fact that standard filters do not work on virus cells. A filter only a few nanometers in diameter is currently being developed that should be capable of removing virus cells from water. [ 8]

### 3.1.3. Nanomaterials; tomorrow's materials:-

Nanotech's "wonder materials" have the Potential to revolutionize how and what we build. One day, carbon nanotubes and other nanomaterials could so radically transform our material palette that paper-thin sheets might hold up entire buildings, forcing us to completely rethink the relationship between structure and skin. [9]

Carbon nanotubes "sheets of graphite just one atom thick, formed into a cylinder "are not only 50 times stronger than steel and 10 times lighter, they are transparent and electrically conductive to boot. Nanotubes are already the building blocks for hundreds of applications, used to reinforce concrete and deliver medication to individual cells. [9]
There are many fascinating examples of nanotechnology applications in new materials. For example, polymer coatings are notoriously easily damaged, and affected by heat. Adding only 2% of nanoparticulate clay minerals to a polymer coating makes a dramatic difference, resulting in coatings that are tough, durable and scratch resistant. This has implications for situations where a material fits a particular application in terms of its weight and strength, but needs protection from an external, potentially corrosive environment – which a reinforced polymer nanocoating can provide. Other nanocoatings can

prevent the adherence of graffiti, enabling them to be easily removed by hosing with water once the coating has been applied. This has the important knock-on effect of improving urban environments, making them more attractive to bona fide citizens and less encouraging to criminals. These kinds of coatings, invented in Mexico, have been shown to work well in parts of Mexico City, transforming seedy crime-ridden neighborhoods into increasingly respectable suburbs. [10]

**3.2. Nanoarchitecture:-**

**3.2.1. Definition of Nanoarchitecture:-**

Nanotechnology + Architecture = Nano architecture. The biggest plans for the future of our built environment are actually very, very small. The eight billion dollar per year nanotechnology industry has already begun to transform our buildings and how we use them; if its potential becomes reality, it could transform our world in ways undreamed of. Nanotechnology has the potential to radically alter our built environment and how we live. It is potentially the most transformative technology we have ever faced, generating more research and debate than nuclear weapons, space travel, computers or any of the other technologies that have shaped our lives.

It brings with it enormous questions, concerns and consequences. It raises hopes and fears in every aspect of our lives social, economic, cultural, political, and spiritual. Yet its potential to transform our built environment remains largely unexplored.

What, for instance, is the future of building if each of us possesses thermo protectant skins that shelter us from the elements? How do we interact with our environment, and with each other, if walls and roofs become paper-thin, permeable, or even invisible? [11]

**3.2.2. Nanoarchitecrure in Interior Spaces:**

Nanotechnology, the ability to manipulate matter at the scale of less than one billionth of a meter, has the potential to transform the built environment in ways almost unimaginable today. Nanotechnology is already employed in the manufacture of everyday items from sunscreen to clothing, and its introduction to architecture is not far behind.

On the near horizon, it may take building enclosure materials (coatings, panels and insulation) to dramatic new levels of performance in terms of energy, light, security and intelligence.

Even these first steps into the world of nanotechnology could dramatically alter the nature of building enclosure and the way our buildings relate to environment and user.

At mid-horizon, the development of carbon nanotubes and other breakthrough materials could radically alter building design and performance.

The entire distinction between structure and skin, for example, could disappear as ultra-light, super-strong materials functioning as both structural skeleton and enclosing skin are developed. [12]

. **Materials:** - [13]

- Nanomaterials like:-

1. Self-cleaning: Lotus-Effect.
2. Self-cleaning: Photocatalysis
3. Easy-to-clean (ETC)
4. Air-purifying
5. Anti-fogging
6. Thermal insulation: Vacuum insulation panels (VIPs)
7. Thermal insulation: Aerogel
8. Temperature regulation: Phase change materials (PCMs)
9. UV protection
10. Solar protection
11. Fire-proof
12. Anti-graffiti
13. Anti-reflective
14. Antibacterial
15. Anti-fingerprints
16. Scratchproof and abrasion resistant

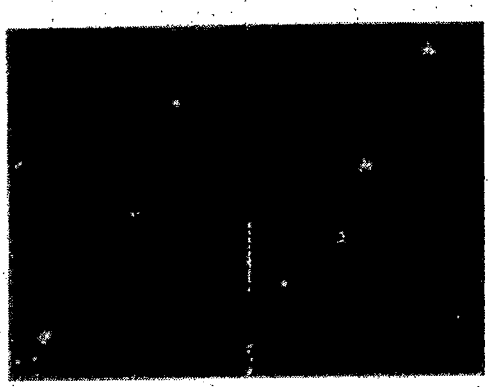
**.1. Self-cleaning: Lotus-Effect:** [13]

-Microscopically rough, not smooth.
-Hydrophobic – water trickles off. This is one of the best-known means of designing surfaces with nonmaterials. The name "Lotus- Effect" is evocative, conjuring up associations of beads of water droplets, and therefore the effect is often confused with "Easy-to-clean" surfaces or with photocatalysis, which is also self-cleaning Self-cleaning surfaces were investigated back in the 1970s by the botanist Wilhelm Barthlott. He examined a self-cleaning effect that can be observed not only in Lotus leaves. They exhibit a microscopically rough water-repellent (hydrophobic) surface, which is covered with tiny knobbles or spikes so that there is little contact surface for water to settle on. Due to this microstructure, surfaces that are already hydrophobic are even less wettable. The effect of the rough surface is strengthened still further by a combination of wax (which is also hydrophobic) on the tips of the knobbles on the Lotus leaves and self-healing mechanisms, which results in a perfect, super-hydrophobic serf-cleaning surface. Artificial "lotus

surfaces", created with the help of nanotechnology, do not as yet have any selfhealing capabilities, but they can offer an effective means of self-cleaning when properly applied. The Lotus-Effect is most well suited for surfaces that are regularly exposed to sufficient quantities of water, e.g. rainwater.

Small quantities of water often lead to water droplet "runways" forming or drying stains, which may leave a surface looking dirtier rather than cleaner. Without the presence of water, the use of such surfaces makes little sense.

In all areas not subject to mechanical wear and tear, the Lotus-Effect drastically reduces the cleaning requirement and surfaces that are regularly exposed to water remain clean. The advantages are self-evident: a cleaner appearance and considerably reduced maintenance demands.



**(Fig.1.)** The diagram shows clearly the difference between conventional surfaces and the Lotus-Effect [13].

**.2. Self-cleaning: Photocatalysis:** - [13].

-Hydrophilic surfaces.
-Deposited dirt is broken down and lies loose on the surface.
-A water film washes dirt away.
-UV light and water are required.
-Reduces maintenance requirements.

Photocatalytic self-cleaning is probably the most widely used nano-function in building construction. There are numerous buildings around the world that make use of this function. Its primary effect is that it greatly reduces the extent of dirt adhesion on surfaces. It is important to note that the term "self-cleaning" in this context is misleading and does not mean, as commonly assumed that a surface need not be cleaned at all. The interval between cleaning cycles can, however, be extended significantly, a fact that is particularly relevant in the context of facility management. Fewer detergents are required, resulting in less environmental pollution and less wear and tear of materials. Likewise reduced cleaning cycles lead to savings in personnel costs and the fact that the dirt adheres less means that it is also easier to remove.

**.3. Easy-to-clean (ETC):** [13].

-Smooth surfaces with reduced surface attraction. -Surface repellence without using the Lotus-Effect. So-called easy-to-clean (ETC) surfaces are water-repellent and accordingly are often confused with other self-cleaning functions such as the Lotus-Effect. However, unlike the latter, easy-to-clean surfaces are smooth rather than rough. These surfaces have a lower force of surface attraction due to a decrease in their surface energy, resulting in reduced surface adhesion. This causes water to be repelled, forming droplets and running off. Easy-to-clean surfaces are therefore hydrophobic, and often also oleophobic. This function is used for coating ceramic sanitary installations and shower cubicle glazing. Wood, metal, masonry, concrete, leather as well as textiles are likewise candidates for hydrophobic coatings. Easy-to-clean surfaces are less susceptible to dirt accumulation (dirt repellent|| ). The benefit: stress-free and easy cleaning saves time and costs.

Water droplets are not always beneficial and can have disadvantageous effects: the drying time is correspondingly longer and this should be taken into consideration for particular areas of application. It is therefore necessary to consider where and how the easy-to-clean function should best be employed; it is that droplets dry individually, leaving behind dirt residues.-

**.4. Air-purifying: -** [13].

- Pollutants and odors are broken down into their constituent parts.

-Does not replace ventilation, but improves air quality.

Though not able to completely purify air, the use of nanomaterials makes it possible to improve the quality of air. It enables unpleasant odors and pollutants to be eradicated.

Nanotechnology makes it possible to chemically decompose odors into their harmless constituent parts. Here the molecules are cracked, giving off steam and carbon dioxide. This approach can also be used to counteract the sick building symptoms (SBS).

Indoors, air purification technology is increasingly being used for textiles and paints. It should be noted that although it is possible to improve the quality of air, this doesn't necessarily make it "good". Other factors such as oxygen content and relative humidity also contribute to the air quality and should not be neglected when sing air-purifying products.

Yet outdoors, the air-purifying capacity of photocatalytic concrete for example provides a possible mean of combating existing pollutants. Recently, building façades, road surfaces and alike, equipped with appropriate coatings, are being implemented in test installations to counteract the effect of industrial and vehicle exhausts. Applications are air-purifying paving stones, road surfaces and paints.

**.5. Anti-fogging: -** [13].

-Clarity for steamed-up surfaces

Due to nanotechnology a permanently clear view is now possible without the use of electricity. The solution is an ultra-thin coating of nanoscalar TiO2, which exhibits a high surface energy and therefore greater moisture attraction. On hydrophilic surfaces moisture forms an ultra-thin film instead of water droplets. It still settles on the surface but remains invisible. The film is transparent, creating a fog-free clear appearance. Bathroom mirrors are obvious candidates for such coating, as are glass surfaces in air-conditioned rooms in the tropics, which tend to cloud as soon as outdoor air streams into a room. Anti-fogging coatings can also be applied to plastics.

Anti-fogging sprays are effective as a temporary means of making surfaces appear clear but the effect doesn't last long. Further application areas for anti-fogging surfaces are currently being developed but are not yet ready for the market place.

Two aspects are common to all anti-fogging variants: condensation itself is not stopped. Instead, and more importantly, it remains transparent and therefore appears invisible. A clear view is possible at all times, simply and effortlessly, without the need for heating, wiping down or a hairdryer.

**.6. Thermal insulation: Vacuum insulation panels (VIPs):** [13].

-Maximum thermal insulation.

-Minimum insulation thickness.

Vacuum insulation panels (VIPs) are ideally suited for providing very good thermal insulation with a much thinner insulation thickness than usual. In comparison to conventional insulation materials such as polystyrene, the thermal conductivity is up to ten times lower. This results either in much higher levels of thermal resistance at the same insulation thickness or means that thinner insulation layers are required to achieve the same level of insulation. In other words, maximum thermal resistance can be achieved with minimum insulation thinness. At 0.005 W/mK, the thermal conductivity of VIPs is extremely low. The thickness of these VIPs ranges from 2mm to 40mm. Vacuum insulation panels can be used both for new buildings constructions as well as in conversion and renovation work and can be applied to walls as well as floors.

The lifetime of modern panels is generally estimated at between 30 and 50 years. It can be applied not just for buildings but also to insulate pipelines, in electronics and for insulating packages, for example for the cool chain transport of medications.

**.7. Thermal insulation: Aerogel: -** [13].

-High-performance thermal insulation.

-Light and airy nanofoam. Aerogel currently holds the record as the lightest known solid material and was developed back in 1931. It is relatively banal: it is simply an ultra-light aerated foam that consists almost 100% of air. The remaining foam material is a glass-like material, and silica. The nanodimension is of vital importance for the pore interstices of the foam: the air molecules trapped within the minute nanpores –each with a mean size of just 20nm – are unable to move, lending the aerogel its excellent thermal insulation properties.

It is used as an insulating fill material in various kinds of cavities – between glass panes, U-profile glass or acrylic glass multi-wall panels – and is therefore well suited for use in external envelopes of buildings. That way aerogels can help reduce heating and cooling costs significantly. Because it is translucent, aerogel exhibits good light transmission, spreading light evenly and pleasantly. In addition to its thermal insulating properties, aerogel also acts as a sound insulator according to the same basic principle.

With its above-average thermal and sound insulation properties aerogel contributes towards energy efficiency, which is its primary functional property. It is an extraordinary high performance insulator and a comparatively new product on the market. A further advantage is its good light transmission and daylight transmittance. From an aesthetic point of view, its light weight makes homogeneous and slender façade constructions possible – all in all a whole catalogue of advantages with great potential.

**.8. Temperature regulation: Phase change materials (PCMs):** [13].

-Passive temperature regulation.

-Reduced heating and cooling demand.

The good thermal retention of PCMs can be used both in new and existing buildings as a passive means of evening out temperature fluctuations and reducing peak temperatures. It can be used both for heating as well as cooling. As PCM is able to take up energy (heat) without the medium itself getting warm, it can absorb extremes in temperature, allowing indoor areas to remain cooler for longer, with the heat being retained in the PCM and used to liquefy the paraffin. Energy is stored latently when the material changes from one physical state to another, whether from solid to liquid or from liquid to gaseous. The latent warmth or cold, which effectively fulfils a buffer function, can be used for temperature regulation.

The predefined, so-called switching temperature, in which the phase changes from one physical state to another occurs in latent heat storing materials designed for construction, is defined as 25oC, as above this temperature the indoor air temperature is generally regarded as being unpleasantly warm. Depending upon the PCM used, to regulate a 5oC increase in temperature only 1mm of phase change material is required in comparison to 10-40mm of concrete.The PCM has a far greater thermal capacity: a concrete wall warms up much more quickly whilst the temperature of a PCM remains unchanged. In the meantime, PCMs have become available in the form of additives that can be integrated into conventional building materials such as plaster, plasterboards or aerated concrete blocks with specific retention properties. In addition to conserving energy by reducing the energy demand for heating & cooling, PCMs are also recyclable and biologically degradable.

**.9. UV protection:** - [13].

-Lasting and highly transparent protection.

There are two kinds of UV protection, both of which are organic and employ additives. Both are typically used in combination: one variant involves the use of UV absorbers that filter out the harmful rays in sunlight before they come into contact with the material itself. As such they need to be on an upper layer and are typically applied in the form of a protective lacquer. The second approach uses so-called free-radical scavengers, which in contrast to the first approach take effect at a later stage.

A prerequisite of protective coatings is that they are transparent so that the coloring and structure of the material beneath is preserved. To achieve this, the individual inorganic UV-absorbing particles in the formulation must be smaller than 15nm in size. Below this size they no longer scatter visible light and become effectively visible.

**.10. Solar protection:** - [13].

-No blinds necessary.

-Glass darkens automatically or is switchable without the need for a constant electric current (memory effect).

The advent of nanotechnology has provided a new means of integrating electochromatic glass in buildings. The primary difference to the earlier product is that a constant electric current is no longer necessary.

A single switch is all that is required to change the degree of light transmission from one state to another, i.e. on switch to change from transparent to darken and a second to change back. The electrical energy required to color the ultra-thin nanocoating is minimal and the switching process itself takes a few minutes.

Photochromatic glass is another solution for darkening glass panels. Here the sunlight itself causes the glass to darken automatically without the switching. Nanotechnology has made it possible to provide an energy-efficient means of solar protection that can also be combined with other glass functions.

**.11. Fire-proof:** [13].

-Highly efficient fire protection.

-Light and transparent.

The German Degussa has produced the aerosil material, a pyrogenic silicic acid used for a number of purposes including the paint industry. The pyrogenic nanoparticles, or nano-silica, are only 7nm large and due to their relatively large surface area are highly reactive. Depending on the desired duration of fireresistance, the highly effective fill material is sandwiched between one or more panes of glass. Standard products are generally between 90 and 380 $m^2$ per gram! The main advantages are the comparatively lightweight of the glass, the slender construction and accompanying optical appearance as well as the long duration of fireresistance. In the event of fire, the fire-resistant layer expands in the form of foam preventing the fire from spreading and keeping escape routes accessible for users and firefighters alike.

The additional layer doesn't exhibit any clouding, streaking or fractures and is practically invisible. An additional side effect is improved noise insulation.

Flame-resistant lightweight building boards, sandwich constructions made of straw and hemp, are a further interesting application by coating the product in a transparent covering of glasslike particles, it's to render its weatherproof and flame-resistant. The glass-like coating also serves as the adhesive and further flam-retardant additives are not required. It is of particular interest for corridors, foyers and meeting rooms, i.e. wherever fire safety is very important.

**.12. Anti-graffiti:** [13].

-Permeable surfaces with permanent anti-graffiti coating.

-Highly hydrophobic and dirt-resistant. An anti-graffiti function is intended as a preventative measure to avoid unsightly graffiti to buildings or construction such as noise barriers, walls and bridges piers. Nanotechnology has provided a new means to protect existing building fabric by anti-graffiti coatings. They are highly effective and are used to make building materials water-repellent. Their extremely hydrophobic properties mean that graffiti can be removed more easily with appropriate detergents. Even porous and highly absorbent materials such as brick, lime sandstone, concrete and other similar materials can be protected efficiently using such nanobased coatings. Although the coating is effectively an impregnation, unlike other systems it doesn't close the pores of the material, allowing the material to retain its vapor permeability. As the material remains permeable potential damage resulting from dampness is avoided. The ultra-thin nanocoating lines the capillary pores without closing them. More dense materials such as compressed concrete in general require less coating material. In addition, the coating also reduces dirt accumulation significantly, making the coating applicable for use on floor surfaces too. The effect of the impregnated coating is a result of several layers of molecules.

**.13. Anti-reflective:** [13].

-Improving solar transmission.

The use of anti-reflective glass to solve the problem of reflection is in itself nothing new. In interior architecture, such glass is used in exhibition design for glass cabinets for example. It's complicated manufacture, which involves applying several layers, means that it is expensive and other disadvantages.

Transparent nanoscalar surface structures, where the particles are smaller than the wavelength of visible light, offer not only an innovative but also a costeffective and efficient anti-reflective solution. Their structure consists of minute 30-50nm large silicondioxide ($SiO_2$) balls. A coating thickness of 150nm is regarded as ideal. The ratio of reflected light reduces from 8% to less than 1%. Another cost-effective means of producing anti-reflective surfaces is the moth-eye effect, the cornea of moths, which are active mostly at night, exhibits a structure that reduces reflections.

The disadvantages of conventional anti-reflective technology, such as the limited spectral region and the complex production process, are eradicated using nanotechnology.

Anti-reflective glass can now be used in large quantities in construction in order to benefit from the increased solar transmission resulting from broadband spectral de-reflection. Of particular interest is the increased efficiency of photovoltaic systems as the entire spectrum of solar energy from 400 to 2500nm is now transmitted. The degree of transmission at low angles of incidence is also much better than before making such systems less dependent upon the angle of the sun. By reducing the amount of under-utilized and therefore lost solar energy, the energy gain and efficiency of the photovoltaic systems is improved, resulting in an overall performance gain of up to 15%.

**.14. Antibacterial:** [13].

-Bactria are targeted and destroyed.

-The use of disinfectants can be reduced.

-Supports hygiene methods – especially in health care environments

Photocatalytic surfaces have an antibacterial side effect due to their ability to break down organic substances in dirt. With the help of silver nanoparticles –for its antimicrobial properties, it is possible to manufacture surfaces specifically designed to be antibacterial or germicidal.

Various products are already commercially available and the product palette ranges from floor coverings to panel products and paints to textiles with an innovative finish that renders them germ-free.

The antibacterial effect of silver results from the ongoing slow diffusion of silver ions. The very high surface area to volume ratio of the nanoparticles means that the ions can be emitted more easily and therefore kill bacteria more effectively. The antibacterial effect itself is also permanent – it doesn't wear off after a period of time.

As the use of disinfectants in health care cannot yet be avoided, it is important that coatings and materials are proven to withstand standard disinfections. In addition, it is also advisable to equip surfaces with an anti-stick function to prevent the buildup of a bio-film of dead bacteria from which new bacteria could eventually grow.

**.15. Anti-fingerprints:** [13].

-No more visible fingerprints.

Steel and glass are popular materials in architecture when used in interiors they have a disadvantage – fingerprints show very clearly and affected by repeated touching. The appearance of cleanliness, whether desirable for aesthetic or hygienic reasons, vanishes when surfaces are covered in fingerprints. An anti-fingerprint coating can offer a suitable solution for this problem and in some cases makes it possible to employ such materials in the first place. With the help of these coatings fingerprint marks are made practically invisible. The coating alters the refraction the light in the same way the fingerprints itself does so that new fingerprints have little effect – one can think of the coating as a kind of enlarged fingerprint. The light reflections on the coating make steel or glass surfaces appear smooth, giving the impression of cleanliness that many users have come to expect.

The coating itself is ultra-thin and steel that has been coated can be bent into shape without the coating breaking or fracturing. This can be useful for the production of particular architectonic details and the coating is used mainly for applications such as lifts, cladding and furniture.

Facility management benefits from this as well as other nanocoatings as they lead to a reduction in cleaning costs. A more recent innovation is a touchproof coating that can also be used for coloring matt glass.

An important aspect here, as with other nanocaotings, is scratch-resistance, which should be assessed carefully depending on where the product is to be used. Antifingerprint coatings are useful for stainless steel and sandblasted glass wherever one can expect people to touch them, i.e. where they are in easy reach. Nanocoatings enable glass and steel to be used for interiors without being impaired by visible finger –and handprints and obviate the need for regular cleaning; in short, to achieve a clean appearance.

**.16. Scratchproof and abrasion resistant:** [13].

-Improvement of scratch and abrasion resistance.

-Transparent coating.

-Creating a basis for durability.

Nanotechnology makes it possible to improve scratch-resistance whilst maintain transparency. Scratch-resistance is a desirable property for many materials and coatings can be applied to materials of different kinds such as wood, metal and ceramics.

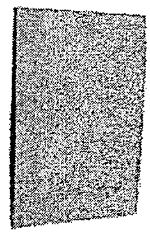
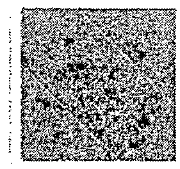
In architectural context, scratchproof paints and varnishes are desirable, for instance to protect the varnished surfaces of parquet flooring or the surfaces of other gloss lacquered surfaces.

Consumers who associate patina with negative connotations such as a "lack of care" and "old and worn" will value a durable gloss that maintains its original appearance.

Scratch-resistant surfaces in combination with UV protection and easy-to-clean properties seem to be a particularly attractive combination for many users, in order to reduce traces of use. Likewise cleanly designed surfaces maintain their appearance better through the use of scratchproof and abrasion-resistant surfaces.

**3.3. Nanomaterial vs. Conventional material; a comparison between nanoceramic tiles and conventional ceramic tiles:** [12].

| **(Table.1.)** | Nano-material Ceramic | Conventional material Ceramic |
|---|---|---|
| Application | | |
| Contract flooring | OK | NO |
| Decorative elements | OK | OK |
| Sanitary Wet rooms | OK | OK |
| Veneer | OK | NO |
| Wall covering | OK | OK |

| | | |
|---|---|---|
| in exterior | | |
| Wall covering in interior | OK | OK |
| Markets | | |
| Construction | OK | OK |
| Home Lifestyle & Personal Care | OK | OK |
| Print, Paint & Coating | OK | NO |
| Advantages | | |
| Antibiotic | OK | NO |
| Breathable | OK | NO |
| Durability | OK | OK |
| Easy to clean | OK | OK |
| Environmental Friendly | OK | NO |
| Flame-resistant | OK | OK |
| Flexible, easy to process | OK | NO |
| Impact-resistant | OK | NO |
| Easy of Mobility | OK | NO |
| Scratch-resistant | OK | NO |
| SVOC free | OK | NO |
| UV-resistant | OK | OK |
| Waterproof | OK | OK |
| |  |  |

## 4. Applications on Nanoarchitecture: - [12].

Nanoarchitecture as the new contemporary architectural style of the 21st century that will revolutionize the architecture world in every way either the way architects think or how they inspire their ideas, the used materials in building, finishing materials, or the way we demonstrate to the world and building users. However, architecture has a small role to play in our daily life but it has a great influence in the world we live in, and its contribution to the daily behavior of man is notably in the way we design buildings.

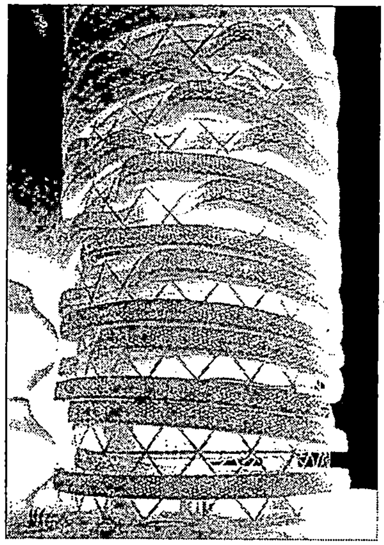
Since the beginning of the 20th century and architects are finding different ways to employ new technologies in architecture, from the industrial revolution and the invention of steam engines, elevators, or the use of steel in buildings construction that has notably changed how the building look like, or how it is built, to the designs, schools and movements; these ideas has led to an emerging philosophies and theories every day that reshaped the architecture of the past century. Nevertheless, the Bauhaus school –leaded by Walter Gropius- between 1919 and 1933 with their main objective to unify art, craft, and technology has became one of the most influential currents in Modernist architecture and modern design coupled with the famous quotation of Mies Van der Rohe "Less is more" together with Le Corbusier who used the Golden Ratio to produce a Modulor system for the scale of architectural proportion and his realization of how the automobile would change human agglomerations has converted the architecture from classical, into Modernism, and International Style.

**4.1. Aplications on Nanoarchitecture in Towers:-**

- Peter Testa, Carbon TOWER: - [12].

| Carbon TOWER: | |
|---|---|
| Architecture | Peter Testa and Devyn Weiser |
| Firm | Peter Testa architects |
| Function | Mixed use high rise |
| No. of story | 40 story |

The Initiative is led by the University of Technology, Sydney through its Institute for Nanoscale Technology, jointly with Commonwealth Science and Industrial Research Organization.



**(Fig.2.)** *A perceptional 3D image of the proposed carbon tower by Peter Testa. [12]*

The Carbon Tower incorporates five innovative systems:

1-precompressed double-helix primary structure.

2-tensilelaminated composite floors.

3-two external filament-bound ramps.

4-breathable thin-film membrane.

5-and vritual duct displacement ventilation.

Studies conducted by Arup suggest that, if built, the tower would the lightest and strongest building of its type.

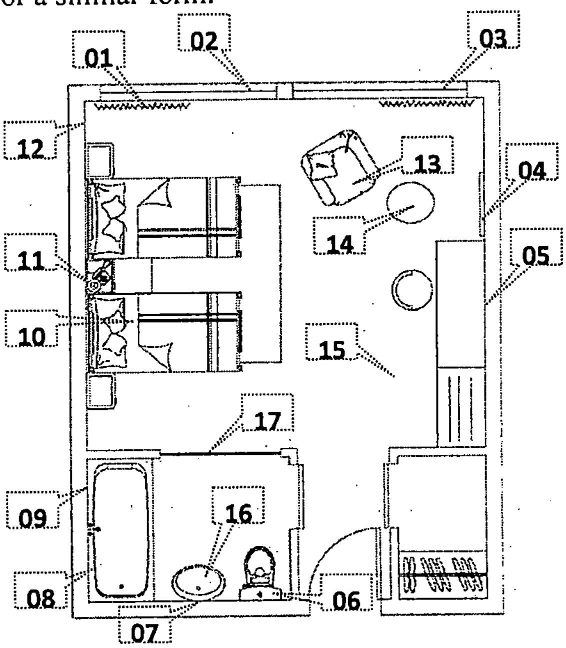
"The complexity of contemporary buildings is an enormous achievement, but we need to question how we came to the point of building with such complexity.

We believe we need to rethink how we assemble buildings." Peter Testa.

**4.2 The holistic application of nanosurfaces in interiors:** [13].

Nano functions have been employed in interior design only occasionally if at all, and more or less by chance. Schematic plan for a hotel room in a clinic or hospital and demonstrate concept for a general strategic approach to using nano functions in interior design. The overall concept varies depending on the respective needs of the different uses. The spaces are optimized through the strategic use of nanosurfaces with regard to aesthetic, economic and ecological concerns.

Improved comfort and cost-effectiveness go hand in hand. Cost assessments should take account not only of the initial expenditure but also the follow-on costs, which are reduced considerably. Despite the fact that these are visionary concepts, they could already be realized today in this or a similar form.




**(Fig.3.)** A schematic plan for a hotel room with a general strategic approach for the use of nanomaterials. [13].

| | |
|---|---|
| 01- Curtains: Air-purifying | 10- Bedding: Anti-bacterial |
| 02- Window: Self-cleaning photocatalytic | 11- Light Switches: Anti-bacterial, non-stick |
| 03- Window: Self-cleaning photochromatic or electrochromic | 12- Wall Paint: Air-purifying |
| 04- TV: Anti-reflective | 13- Upholstery: Air-purifying |
| 05- Wall Paint: Air-purifying | 14- Glass Table: Anti-fingerprints |
| 06- W.C.: Easy to clean | 15- Carpet: Air-purifying |
| 07- Mirror: Anti-fogging | 16- Sanitaryware: Anti-fingerprints |
| 08- Bathtub & Shower Screen: Easy to clean, non-stick | 17- Frosted Glass: Anti-fingerprints |
| 09- Walls: Nanoparticles ceramic covering | |

## 5. Conclusions:-

**1-** It would be difficult to deny the potential benefits of nanotechnology and stop development of research related to it since it has already begun to penetrate many different fields of research. However, nanotechnology can be developed using guidelines to insure that the technology does not become too potentially harmful. As with any new technology, it is impossible to stop every well-funded organization which may seek to develop the technology for harmful purposes. However, if the researchers in this field put together an ethical set of guidelines (e.g., Molecular Nanotechnology Guidelines6) and follow them, then we should be able to develop nanotechnology safely while still reaping its promised benefits.

**2-** The applications of the nanotechnology in architecture can vary widely from early stages of design to the final touches of finishes and throughout the building's lifetime.

**3-** Disruptive technologies such as nanotechnology give us the opportunity to move into new high value-added areas both by creating new architecture and by radically changing traditional ones.

**4-** We need architects, scientists and technologies to give careful thought to any ethical, cultural, architectural and environmental issues raised by nanotechnology, to say whether any new regulatory controls are required, and to enter into an open dialogue with the public.

**5-** It is an opportunity we must seize, and the governments shall put in place the public goods such as a world-class science and technology base, incentives for knowledge transfer and high educational standards, to enable companies to put innovation at the center of their strategies for the development of technology.

## 6 - References

1. **Human Comfort and Health Requirements** http://courses.washington.edu/me333afe/Comfort_Health.pdf.

2. **Government Investment in Nanotechnology** Fifth Report of Session 2003, 04 Report Volume I Ordered by The House of Commons. http://www.publications.parliament.uk/.

3. **NT Introduction** http://www.etcgroup.org/.

4. **Nanoarchitecture Introduction.** Yeadon, Peter. Year 2050: Cities in the Age of Nanotechnology, http://sensingarchitecture.com/523/nanotechnology-and-new-materials-for-architecture/

5. **What is human comfort?** http://uk.ask.com/what-is/what_is_human_comfort

6. **Comfort in Buildings.** http://www.natural-building.co.uk/comfort.html

7. **Nanotechnology.** http://en.wikipedia.org/wiki/Nanotechnology.

8. **Nanotechnology Applications.** http://understandingnano.com/.

9. **The Nano Revolution: A science that works on the molecular scale is set to transform the way we build**. Elvin, George. The Architect Magazine. http://www.architectmagazine.com/industrynews.asp?sectionID=1006&articleID=492836&artnum=2.

10. **What's nanotechnology?** http://www.nano.org.uk/whatis.htm.

11. **Definition of Nanoarchitecture.** http://www2.arch.uiuc.edu/elvin/nanotech.htm

12. **Nanoarchitecture Application.** http://greendimensions.wikidot.com/nanotechnology-in-architecture.

13. **Nano Materials in architecture, Interior architecture and Design.** Leydecker, Sylvia. (2008).

14. **The Nano Towers.** http://www.archicentral.com/the-nano-towers-by-allard-architecture-17754/.

15. **Introduction to Nanotechnology Course – Mansoura University Nanotechnology Center.**

16. Dr. Dnial Schodek & Others "**, Smart Materials and Technologies**", Harvard University, Elsevier Ltd, 2nd edition 2006.

17. Peter Gossel , " **Architecture In The 20th Century** " Bendikl-Taschen Edition ,2008.

18. Philip Godido, "**Architecture in the Emirates** ", Taschan Press, 2008.

19. Fanger, P. O.: **Thermal Comfort**: Danish Technical Press 1980.

20. Martin Evans, "**Housing, Climate & Comfort** ", Jon Willy & Sons, New York, 1985.

21. T.A.Markus, **Building Climate & Energy**, Bitman, 1989.

22. Givoni .B, "**Man, Climate & Architecture** ", 4th ed, London, Applied Science Ltd, 1990.