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Application of Nanotechnology in the Concrete Industry Improve the Performance of Sustainable Buildings

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Abstract

Today, with the growing progress of science and technology and increasing greenhouse gases and global warming, we perceive many applications in all fields of sustainable architecture. Amongst, Nano scale science and engineering leads to better understand the nature and conserve resources. It seeks comfort in the indoor and outdoor, finding a new class of materials with high performance and save costs .Nature of nanotechnology, molecule composing, by approaching from down to the top scale is (between 1 to 100) nanometer. Nano is derived from word nano means small. Early studies in this field back to 1990s which in this regard concrete industry the strength and durability is important. Much research suggests the effectiveness of nano material in concrete structure. In this study we are proposing the efficacy of nanotechnology in improvement of cement and concrete and achieve the high performance of concrete and by utilizing the produced materials from nanotechnology gain the sustained architecture.

Keywords: nano technology, nanoparticles, enduring development, save cost, concrete, cement

Introduction:

With the increasing development of nanotechnology, using tiny nanoparticles and Nanomaterial also increased in modern technologies (Seaton, 2006). The technology with speech of Richard Feynman, a theoretical quantum as (it is down a lot of space) emerged in 1959 (R.Feynman, 1961) and at the end of the decade in 1980, shortly after the invention of the AFM, STM, appeared in the industry (Oriakhi, 2004) and was predicted at the time that ready-mixed concrete and concrete products are among the 40 industries. (Bittner et al, 2009).

A lot of research is doing in this area in concrete buildings to understand the basic science level technologies such as: microscope FIB, SEM, AFM for nano-scale study made (Mesgerian et al., 2013).

In terms of construction, concrete is a composite material wrapped with multiple scale is the most widely used building materials with a view to developing concrete construction worldwide shortage of cement in most countries, the researchers went on to found the material to replace this matter and can the cement, concrete properties improved. (UPDATE 10-year strategy document nanotechnology development) as a result of the investigation, of pozzolan, such as fly ash, slag, silica fume, rice hull ash, etc., which have healing effects are obtained (Kazberuk and Lelusz, 2007).

Concrete and other cement based materials can be used as the main material of human civilization construction of infrastructure due to its low cost, low power consumption and availability of raw materials are considered (Keyvani, 2007).

Concrete structure:

Concrete is material with nano-structure, multi-phase and irregular crystalline phases with different components that the structure of micrometer to nanometer dimensions. (Florence and Konstantin, 2010) nanostructured calcium-silicate-hydrate phase, a non-crystalline (C-H-S) causes the adhesive to the concrete components together. (Chong and Garboczi, 2002)

Nanotechnology in concrete:

Recent research activities in the field of nanotechnology in concrete: the evaluation inherent in the cement hydration, the effect of adding nano-silica concrete, adding nano particles of cement, concrete and cement overlays and observe their effects on behavior and profile is created (Perumalsamy and Ken, 2006).

Nano particles of cement:

Cement in in the industry as a powder produced and consummated. Cement particles and micro dimensions are generally in the range of mm. The nano particles of cement to improve the performance of cement are proposed. Two ways to build nano particles of cement is proposed: 1. cement particles by crushing mill powerful (top-down) and 2 Chemical substances (component in total).
Cementitious adhesives that are created using nano particles of cement, less development time and initial compressive strength than ordinary cement (Kriven, 2005). One of the benefits of nano-scale crystals in using the nanoparticles are formed, filling empty spaces and cavities in the cement matrix. Add nanoparticles, nano-crystals can be formed, leading to an increase in compressive strength, tensile and shear (Golabchi et al., 2011).

Nanoparticles in oxide Iron:

It is observed that the use of nanoparticles of iron oxide in the cement increases the compressive strength and flexural as well as the ability to cause self-monitoring (Self-sensing capabilities) is concrete. (Li et al, 2004)

Nanoparticles Aluminum oxide:

Add to the mixture of aluminum oxide nanoparticles resulted in a significant increase in the modulus of elasticity of concrete. It is observed that the addition of 5% aluminum oxide nano, the modulus of elasticity of concrete has increased 143 percent but had no significant effect on concrete strength (Li et al, 2006).

Nanoparticles of titanium dioxide (Tio2):

Titanium dioxide nanoparticles improve concrete characteristics of the building is used as an anti-reflective coating suppliers. TiO2 is a white concrete containing certain radiance and luminosity to effectively maintain. The buildings are made of ordinary concrete without such features. In fact, nanoparticles of titanium dioxide (titania) is a photocatalysts are the catalyst that works with light.

The nanoparticles act as a catalyst that helps large and active molecules into smaller molecules or particles with less years of break. The presence of titanium dioxide in materials and wall damage level of air pollution and help to stay. Figure (1)

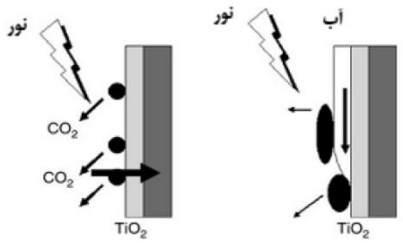


Figure 1: A schematic self- cleaning mechanism of the hydrophilic surface of titanium dioxide (Ghasemi, Parhizgar: 2009)

This oxide in three structures: anatase, rutile and brocket founded, the anatase is most of the property is photocalist. Surfaces containing titanium dioxide (Tio2) can look at the effect of sunlight are clean. Water flow on the surfaces self-cleaning feature can increase the cleaning properties of titanium dioxide is ultra-hydrophilic surfaces (Ghasemi and Parhizgar 2009) Fig. (2)



Figure 2: self-cleaning surface glaring white outer walls, concrete combined with nanoparticles of titanium dioxide (www.richardmeier.com)

Natural and industrial pollutants such as NOx, carbon monoxide, VOC's, chloro phenols and aldehydes caused by cars and industrial waste, as a result of photo-catalyst and catalyst to help break very active nanoparticles of titanium dioxide (Murata et al, 1999). Joobly Church was an example in this context that in Rome, Italy. According to the researchers, the use of nanoparticles of titanium dioxide in addition to the self-cleaning properties, suppliers, increasing speed and reducing setting time Hydration (Jayapalan and Kurtis, 2009) and increased flexural and compressive strength of concrete too. One of the disadvantages of this method is disruptors its performance over time. (Lackhoff et al, 2003)

High-performance concrete (HPC):

High-performance concrete (HPC) is one of the challenges that have arisen in the field of construction materials. This type of refractory concrete of composite materials and composite materials is the durability of the multi-phase composite and complex. Properties, behavior and performance of concrete and cement concrete depend on the nanostructured material that creates adhesion, cohesion and integration.

Conventional methods for the development of high-performance concrete mix design often includes various parameters, including different types of fibers are normal and reinforced concrete. In the concrete case specifically, in addition to the durable performance and better mechanical properties, high-performance concrete multi-purpose (MHPC) had the additional properties, including the properties of electromagnetic and deployment capabilities in structures nuclear (radiation protection) and increase its effectiveness in energy conservation and other buildings named. (Pars, 2011) concrete high-performance, lightweight structures can be used Brass. (Ferric et al, 2013)

Nano silica amorphous:

In the concrete industry, one of the most well-known silica materials that plays an important role in adhesion and high-performance concrete (HPC). Silicia Phiom or micro-silica is the typical product that has a diameter of about 1.0 to 1 mm and a silicon oxide is about 90% (Pars, 2011)80 years ago micron-sized silica for use extensively in cement based concrete is used. It has been proven that the use of smaller particles of silica fume concrete strength has been increased (www.nano.ir)

Adding nano-silica concrete increased compressive strength, tensile and flexural strengths, reduce the setting time and loss of water in concrete permeability and higher resistance against chemical attacks.

Tests conducted on nano-silica, have shown that these particles are problematic not only for the environment but also provide better results compared to micro silica (Sobolev and Ferrada, 2005). Research has shown that adding more of the micro-silica nano-silica increases the resistance of concrete (Qing et al, 2007) add 10% nano-silica concrete compressive strength was increased 26 percent while the value increased by 15 percent silica fume compressive strength of concrete found (Li et al, 2004). Even adding small amounts of nano-silica 25/0 percent of the 10 percent increase in compressive strength and flexural strength is 25 percent. (Sobolev, 2005)

Now silica in concrete construction resistant to acids used for cooling towers of the power plant that improves the structure and chemical properties have been concrete. To use this acid resistant concrete can cover the cost of routine maintenance are organic. (Hosseini and Yazdi, 2012)

With the development of nano-materials, concrete spray (sprayed concrete) produced water, lost in the short term by adding nano-silica concrete Randy was faster. Add cement nanoscale materials can improve its performance characteristics. In 2004, Lee discovered that nano-silica cans dramatically compressive strength of concrete containing fly ash particles with high volume; add it at an early age. (Golabchi and Taghizadeh, 2010) Figure (3)



Figure 3: Image microscopic spherical particles of fly ash (Newman and Choo, 2003)

High-strength concrete (HSC):

In recent years, high-performance concrete examples it can have more improvements in the building Petronas (Malaysia 1998), Jin Mao Tower (1999, China) see. (Halis G, 2007) According to the Committee ACI363, so-called high-strength concrete with a minimum compressive strength of the concrete used is equal to 41 MPa. (H Beshr et al, 2003)

Self-healing concrete:

Recent research capsules containing fine filler where cracks in the concrete mixture are placed. When the concrete cracks caused material inside the capsules break and leave it fills the space. (Golabchi et al., 2011) Figure (4)

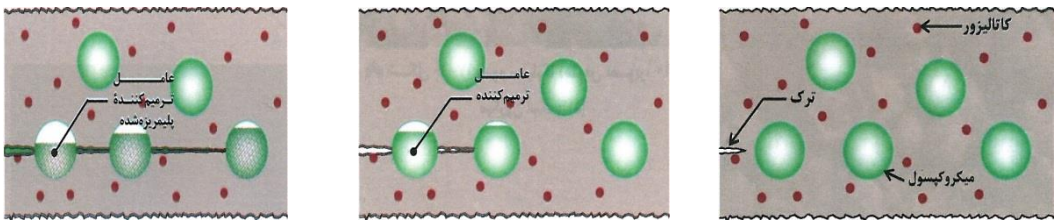


Figure 4: the mechanism of self-healing concrete cracks (Golabchi et al., 2011)

Control and prevent the occurrence of cracks in the concrete structure is one of the main problems. So self-healing is one of the greatest phenomena to overcome the problem of loss of functional integrity (which occurs as a result of damage to the material) is used. Self-healing process, must immediately after the injury occurred automatically and scope of the damage, their integrity before damage similar to what was achieved. With the advent of nanotechnology to the concrete industry self-healing composites, smart structures by identifying failures and recalls the spontaneous healing. (Nanotechnology Initiative Council, 2015)

Light Concrete:

Also, the use of nano concrete in the construction of economically affordable, because due to reducing crime, building dead load) is the weight of the structure itself (the dimensions of their column, beams and ceilings thickness is reduced, which makes saving building materials such as cement and steel. Concrete nano proper insulation against heat, cold and sound, because of the tiny pores in the concrete. Concrete at least 10 times normal concrete is sound and heat insulation.

So the acoustic and thermal insulation of the concrete in such a way that in most cases require the use of additional layers of insulation will not be partial or total. This is cost-effective and economically. (Nanotechnology Initiative Council, 2015)

Phase-change material (PCM):

One of the most interesting fields of research, phase-change material (PCM), which combined materials such as plaster or concrete foam (autoclave) are set and action to improve the temperature in the building. That is, when the weather is cold PCM with the heat generated by the heat of condensation, facade heat and in summer the heat by the melting process and a cooling effect is created in the facade. PCM-based paraffin in polymer capsules is packed too small, well-played combination materials without influence on its mechanical properties (Hosseini and Yazdi, 2012). Figure (5)

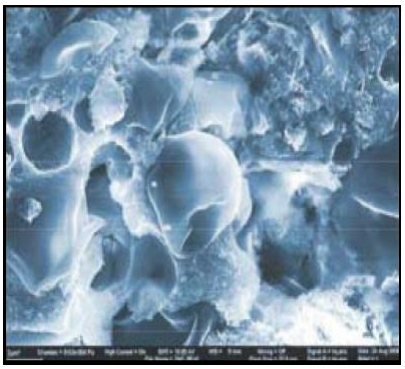


Figure (5): phase-change material to adjust the temperature in the building, placed in the concrete matrix composition. (BAM, Berlin)

Zycosil:

Zycosil new generation of nano technology, which is used to waterproof concrete and construction materials and protect them against heat and UV and weathering made. It is very small because of the size (4 to 6 nm) and high leverage (3 to 5 mm), against wind erosion, constant shower of rain and UV resistant. This product is the first waterproof material, with water-based nano-technology in the world, which means it complies with the highest standards of VOC. Zycosil dissolves in water and forms a clear solution as well as cost-effective and environmentally friendly. (Sodagar.com)

The challenges of nanotechnology in the concrete industry:

Challenges that must be solved before expanding the use of nanotechnology in the concrete industry, such as: distribution of nano-materials, nano-materials compatibility with cement, processing, production, safety, issues related to transportation, mass production and costs, in addition to the introduction of these new materials to the community through social infrastructure requires increased and understanding its impact on the environment and human health is, however, what is clear is that, now, after 50 years of famous article Feynman nanotechnology scientists and engineers in changing views about one of the oldest man-made material, is concrete. (Florence and Konstantin, 2010)

Conclusion:

- With the high cost of cement, can be used instead of alternative materials, use of this material, in addition to economic aspects, to improve concrete characteristics, such as permeability, durability and reliability of the concrete against chemicals.
- Use of nanoparticles will improve the mechanical properties and increase the quality of cement and concrete. It also covers nano-particles and the influence of external destructive elements into the concrete, which reduces the durability and reliability and increase the rate of degradation can be prevented.
- Different nanomaterial, can determine basic building materials, such as strength, durability and lightness to improve the safety of buildings and structural health monitoring can also be used. In this paper, the effects of nanoparticles, the concrete industry and challenges in the industry have been discussed.
- For the future research, a well-designed experiment, such as full factorial design of experiments (Mobin et al., 2016), can be utilized to have more accurate results.

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