REVIEW PAPER ON NANOMATERIAL'S AND ITS USE IN CIVIL ENGINEERING

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Abstract

In recent times researches have shown that nanomaterial and nanotechnology have a great extent in the filed like healthcare, science, cosmetics and engineering. Building materials domain is one of the main beneficiaries from these researches with applications that will improve the characteristics of concrete, steel, glass and insulating materials. Materials like CNT, TiO2,nano silica, Copper nanoparticles, Silver nanoparticles etc. this review paper lays emphasis on the nanomaterials and its use in civil engineering. *Moreover, nanomaterials applied to the surfaces of structural elements of the building can contribute to environmental cleaning.*

Keywords: nanomaterial, nanotechnology, construction, nanoparticle

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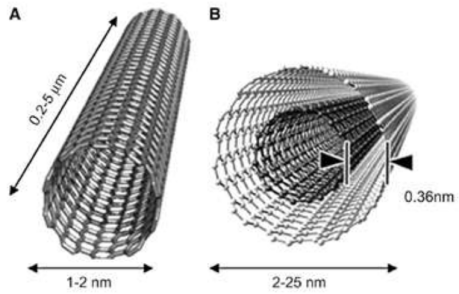
Introduction to nanomaterial

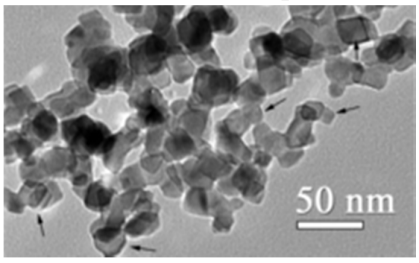
Nanomaterials research presents wide scope for the development of various solutions in the field of engineering, biomedical, cosmetics and electronics. Altering their molecular and atomic states results in unexpected outcomes, which may not be possible by using the materials in their original states. The use of nanotechnology in construction involves the development of new concept and understanding of the hydration of cement particles and the use of nano-size ingredients such as alumina and silica and other nanoparticles. With the help of nanotechnology, concrete is stronger, more durable and more easily placed, steel is made tougher, glass is self-cleaning and paints are made more insulating and water repelling.

Carbon nanotube



Carbon nanotubes are a form of carbon having a cylindrical shape, the name coming from their nanometre diameter. They can be several millimetres in length and can have one layer or wall (single walled nanotube) or more than one wall (multi walled nanotube) **(Lu *et al*., 2010)**. Carbon nanotubes are probably one of the most highly researched materials of the 21st century, due to their higher mechanical properties compared to all other types of nanomaterials. The remarkable properties of CNT's are the cause of intense research around the world on possible applications. For example, they have 5 times the Young's modulus and 8 times (theoretically 100 times) the strength of steel whilst being 1/6th the density.

Titanium Dioxide Nanoparticles (TiO_2)



Titanium dioxide nanoparticles, also called ultrafine titanium dioxide, are particles of TiO_2 with diameters less than 100 nm. Titanium dioxide has become part of our everyday lives. In this respect, combining TiO_2 nanoparticles with cement-based construction materials seems to be a good solution, due to its strong photocatalytic activity, which results in an environmental, self-cleaning and self-disinfection, high stability, pollution remediation and relatively low cost **(Hashimoto et al. 2005)**.When TiO_2 is exposed to UV light, it becomes increasingly hydrophilic (attractive to water), thus it can be used for anti-fogging coatings or self-cleaning windows.

Silicon dioxide nanoparticles

Silicon dioxide nanoparticles, also known as silica nanoparticles or nanosilica, are the basis for a great deal of research due to its function with a range of molecules and polymers. Nano-SiO_2 could significantly increase the compressive strength of concretes containing large fly ash volume at early age, by filling the pores between large fly ash and cement particles. In civil engineering there are many benefits as reinforcement in mechanical strength in concrete; coolant, light transmission, and fire resistance in ceramics; flame-proofing and anti-reflection in windows.

Other nanoparticles

There is many other nanomaterials use in construction. Some of them are *Iron oxide nanoparticles, Copper nanoparticles, Silver nanoparticles*, *Quantum dots,* Wolfram (Tungsten) Oxide Nanoparticles *etc.*

Nanomaterials in civil engineering

Nanomaterials in Cement and Concrete

Portland cement is the most widely used construction material. Concrete is a macro-material strongly influenced by its nano-properties. The addition of nano-silica (SiO2) to cement based materials can control the degradation of the calcium-silicate hydrate reaction caused by calcium leaching in water, blocking water penetration and leading to improvements in durability **(Mann, 2006).** A number of investigations have been carried out to develop smart concrete using carbon (**Chong *et al.*, 2002)** and it has been found that instead of carbon fibres, nano-carbon tubes added with nano-cement are more effective. Another type of nanoparticle added to concrete and cement to improve its properties is titanium dioxide (*TiO2*). *TiO2* is a white pigment and can be used as an excellent reflective coating. Since *TiO2* breaks down organic pollutants, volatile organic compounds, and bacterial membranes through powerful catalytic reactions, it can therefore reduce airborne pollutants when applied to outdoor surfaces. Additionally, it is hydrophilic and therefore gives self-cleaning properties to the applied surfaces.

Nanomaterials in Steel

Steel is a major construction material. Its been widely used since late 19^{th} century. Fatigue is a significant issue that can lead to the structural failure of steel subject to cyclic loading, such as in bridges or towers. Stress risers are responsible for initiating cracks from which fatigue failure, the research shows that the addition of copper nanoparticles reduces the surface unevenness of steel which then limits the number of stress risers and hence fatigue cracking. The carbon nanotubes have little application as an addition to steel because of their inherent slipperiness, due to the graphitic nature, making them difficult to bind to the bulk material **(Mann, 2006)**. And addition of nanoparticles of magnesium and calcium leads to an increase in weld toughness. Vanadium and molybdenum nanoparticles improve the delayed fracture problems associated with high strength bolts, reducing the effects of hydrogen embrittlement and improving the steel micro-structure

Nanomaterials in Glass

Fire-protective glass is another application of nanomaterial. This can be done by using a clear coating in layer sandwiched between glass panels formed by fumed silica (SiO2) nanoparticles which turns into a rigid and opaque fire shield when heated. Nano-TiO2 coatings can also be applied to building exteriors to prevent sticking of pollutant and hence reduce maintenance costs. Due to the nanoparticles photocatalytic reactions, the organic pollutants, volatile organic compounds and bacterial membranes are decomposed. The electrochromic coatings are being developed that react to changes in applied voltage by using a tungsten oxide layer; thereby becoming more opaque at the touch of a button. Because of the hydrophobic properties of TiO2, it can be applied in self-cleaning or in antifogging coatings windows.

Nanomaterials in Coating, Detection and Fire Protection

The coating can be done using nanoparticles of different nanomaterials, For example coating works in two stages. First, using photocatalytic process, nanosized TiO2 particles in the coating react with ultra-violet rays from natural daylight to break down and disintegrate organic dirt. Secondly, the surface coating is hydrophilic,

which allows rainwater to spread evenly over the area and let's glass to wash the loosened dirt away. It can therefore reduce airborne pollutants when applied to outdoor surfaces.

Nano sensors enable self-sensing and detecting capability for developing smart structures. They can monitor and/or control the environment conditions like temperature, moisture, smoke, noise, etc. and the structure performance stress, strain, vibration, cracking, corrosion etc. during the structure's life.

On the other hand its has great fire resistant property like It has been found that nano-cement mixing with carbon nanotubes (CNT) with Cementous material to fabricate fibre composites has outstanding properties of high strength (**Makar et al., 2003**) and fire resistance.

Merits and Demerits of Nanomaterial

Merits:

- Self-repairing asphalt, healing and rejuvenating nano agents for asphalt **(Partl et al.2006)**, and self-assembling polymers improve asphalt mix.
- Nano-modified concrete cuts down construction schedules while reducing labour-intensive and expensive tasks. Also it can reduce the cost of repair and maintenance.
- The market for fire protection systems totalled approximately $45 billion in 2004 and is expected to grow to more than $80 billion by 2010 **(HKC)**
- Nano sensors embedded in infrastructural materials can provide, at minimum cost, fully integrated and self-powered failure prediction and forecasting mechanisms for high-capital structures e.g., reservoirs, nuclear power plants, and bridges.

Demerits:

- Nano particles being very small in size have the potential to negatively affect the respiratory and digestive tracks and the skin or eye surface thus exposes workers to hazards.
- Small production volumes and high cost remain the main barriers to the use of nanotechnology **(The Royal Society 2004)** .

Effect of nanomaterials on environment

The effect of various Nanomaterials on environment is debatable in nanotechnology and environmental researches .Various ongoing investigations have focused on the uncertainty regarding the potential effects of material that exist on the Nano-scale with properties that are different than when using the material on a micro or macro scale . In the atmosphere the nanoparticles move from higher concentration to lower concentration. Due to its light weight the particles can travel at great distance hence affecting a large area. there are potential problems in this regard include leaching of materials into groundwater, releasing materials into air through the generation of dust and exposing potentially harmful materials during construction and maintenance operations. The nanomaterials have become a double-edged sword to society. More researches and practice efforts are needed with smart design and planning to construction projects that can be made sustainable and therefore, save energy, reduce resource usage, and avoid damages to the environment.

Conclusion

The nanomaterials have shown great extent in field of science due to which it is rapidly growing in the field of research and development. This paper shows the present and futurist applications in the field of civil engineering by the use of nonmaterial's like CNT, $TiO_{2,}$,nanosilica etc. We came to know about the merits and demerits of nanomaterials and technology, and its impact on the environment. There are certain challenges that in this field that we have to come over with for more sustainable use of these materials. Furthermore this field is rapidly growing for creating more advance products. By studying this paper we can conclude that we could use these materials to create a strategic roadmap which could help us to have a greater impact in the field of civil engineering.

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