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SMART NANO-MATERIALS IN CONSTRUCTION INDUSTRY

From The Constructor

Concrete, steel, glass, and timbers are the most common materials, being used in the field of modern construction. In the following table, some important characteristics of the above-mentioned materials are tabulated.

Material	Young's Modulus (GPa)	Tensile Strength (GPa)	Density ($g.cm^{-3}$)
Concrete	30	0.007	2.3
Steel	208	1.0	7.8
Glass	50-90	Negligible	2-8
Timber	16	0.008	0.6

If we compare these properties with those of a carbon nanotube, the results are astonishing. A carbon nanotube has a Young's modulus of 1054 GPa, a tensile strength of 150 GPa and a density of 1.4 $g\text{-}cm^{-3}$. Thus a carbon nanotube has strength of 150 times that of steel and at the same time approximately six times more lighter.

Based on the above statistics, it was thought (in UK Delphi Survey 1990), that the Construction industry would benefit the most from Nanotechnology. However, Construction industry lags behind other industrial sectors in terms of appealing investment from large corporate sectors.

Nano-technology is a technology that enables to develop materials with improved or totally new properties. It is an extension of the sciences and technologies already developed for many years to examine the nature of our world at an ever smaller scale. A nanometer is one billionth of a meter. Nano particles is defined as a particle that has at least one dimension less than 100nm. The size of the particle is very important because at the length scale of the nanometer, i.e. 10^{-9} m, the properties of the material actually become affected.

Carbon nanotubes and nanofibers present an important classification of nano-materials. They are made from Graphene. Graphene is defined a monolayer of carbon atoms packed into a honeycomb lattice. It can also be defined as an atomic-scale chicken wire made of carbon atoms and their bonds. If graphene layers are arranged as stacked cones, cups or plates, it is known as Carbon nanofibers (CNF) and if the grapheme layers are wrapped into perfect cylinders, they are termed as Carbon nano tubes (CNT).

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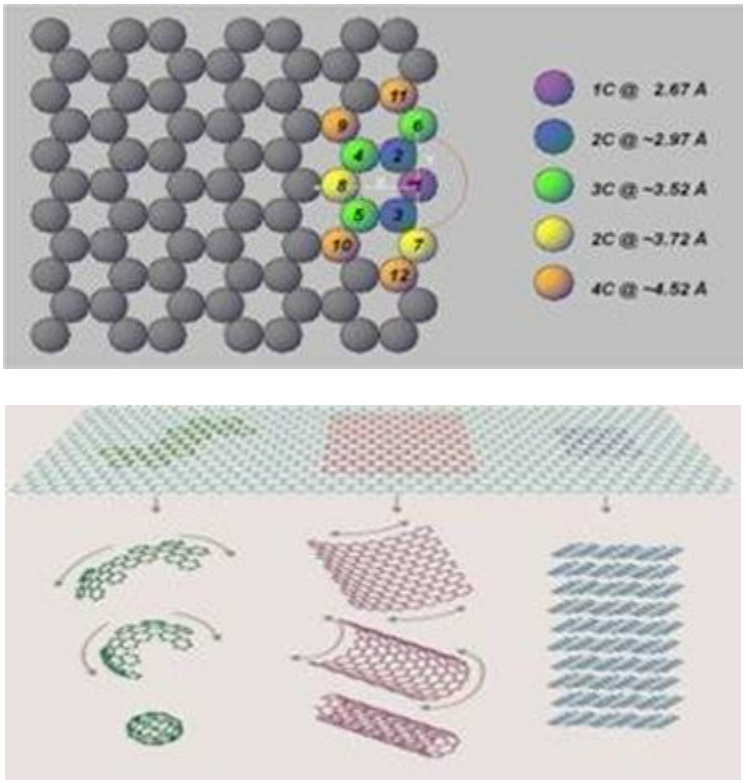

Graphene layer, Carbon Nano Tubes, and Carbon Nano Fibers

Nano composites are produced by adding nano-particles to a bulk material in order to improve the bulk material properties. Materials reduced to nano-scale can suddenly show very different properties compared to what they exhibit on a macroscale, enabling unique applications. For instance, opaque copper substances become transparent and inert platinium materials attain catalytic properties.

Nano-technology is a dynamic research field that covers a large number of disciplines including construction industry. Concrete is a material most widely used in construction industry. Concrete is a cement composite material made up of Portland cement, sand, crush, water and sometimes admixtures. Interest in nano-technology concept for Portland-cement composites is steadily growing. The materials such nano-Titania (TiO_2), Carbon nanotubes, nano-silica (SiO_2) and nano-alumina (Al_2O_3) are being combined with Portland cement. There are also a limited number of investigations dealing with the manufacture of nano-cement. The use of finer particles (higher surface area) has advantages in terms of filling the cement matrix, densifying the structure, resulting in higher strength and faster chemical reactions (e.g. hydration reactions).

Nano-cement particles can accelerate cement hydration due to their high activity. Similarly, the incorporation of nano-particles can fill pores more effectively to enhance the overall strength and durability. Thus nano-particles can lead to the production of a new generation of cement composites with enhanced strength, and durability.

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According to researchers, following is a list of areas, where the construction industry could benefit from nano-technology.

1. Replacement of steel cables by much stronger carbon nanotubes in suspension bridges and cable-stayed bridges

2. Use of nano-silica, to produce dense cement composite materials

3. Incorporation of resistive carbon nanofibers in concrete roads in snowy areas

4. Incorporation of nano-titania, to produce photocatalytic concrete

5. Use of nano-calcite particles in sealants to protect the structures from aggressive elements of the surrounding environment

6. Use of nano-clays in concrete to enhance its plasticity and flowability.

7. Urban air quality could be improved by if the civil structures are treated with nano TiO2

Cable-Stayed and Suspension bridges

New Jubilee Church (Rome, Italy) made of nano photocatylatic concrete