Pathway of Nano Particles in Building Construction

[1] Dr. A. S. Kanagalakshmi,
[1]Professor,
Department of Civil Engineering,
Panimalar Engineering College,
Chennai, India.

[2] K. Sharankumar,
[2]Asst. Professor,
Department of Civil Engineering,
Panimalar Engineering College,
Chennai, India.

[3] P. Dhivyadarshini, [4] M. Sowmiya, [5] S.J. Shebatini Seljin
[3,4,5] Student,
Department of Civil Engineering,
Panimalar Engineering College,
Chennai, India.

Abstract: **Nanotechnology is a growing discipline in research and developments. It engages scientists in involving themselves in the production of efficient nanomaterials and study of their performance. Nanotechnology has been majorly concerned about its contributions in the field of microbiology, medicine, electronic, chemical and material sciences. However, its involvement has been increasing in the field of construction. The objective of the study is to review the role of nanotechnology in civil engineering applications. It serves as a Phase Change Material (PCM) making it energy efficient. Nanoconrete enhances various properties with different nanomaterials. Nanotechnology in wood and glass improves the bond between the fibres. Nanotechnology in coating makes the surface easy to maintain and not to be spoiled by dirt. It has been found that the role of nanotechnology in the civil engineering discipline will definitely result in a new generation of construction materials with increased performance, strength, durability and other properties.**

Keywords: Phase Change Material, Nano - Flex, Aeropan , Nano-Composite, Nano - Tube, Nano - Clay

I. INTRODUCTION

Nanotechnology is a wide field and has immense contribution in various fields of science and technology. It has evolved as a revolutionary technology and greater is what these small nanoparticles can do to various materials. Nanotechnology in civil engineering serves as a platform for the advancement in construction field. Nanotechnology is specially applied to the varied construction materials. Concrete and steel being the major construction materials requires additional ingredients to improve their performance. Thus, nanoparticles are added to enhance the strength and properties of these materials. The addition of nanoparticles contributes phase change materials.

Nanomaterials in concrete would be Nano-silica, Nano-clay and Nano-composites. Nano-flex can be used in steel. Apart from all these nanotechnologies can also be added to increase bond strength between two substances and can also serve as coatings.

The different types of nanomaterials used in construction, their application, advantages and disadvantages are explained in this paper.

A. Nano materials in building

Nano Insulation Materials (NIM) are widely used order to limit the wall thickness due to its low thermal conductivity. Nansulate is a Nano-insulation material which is common in Iran that forms a thin layer of insulation having high resistance to microbiological attack, Industrial Nanotech (2013). It is a liquid coating, which dries into a thin layer providing exceptional insulation, corrosion protection and prevents mold. Nansulate reduces energy consumption, lowers carbon emission, improves workers safety and greatly reduces the maintenance cost.

B. Nanomaterials in concrete:

Use of nanomaterials in concrete, also known as Nano concrete enhances the various properties of concrete like strength, density, durability and workability. Nanomaterials are those materials of size 200nm but for the purpose of study in concrete the nanomaterials must be at least of 500nm. Microstructure discrepancies in concrete such as porosity, micro-void, deterioration due to silica- alkali reaction can be eliminated due to the addition of nanomaterials in concrete. High density concrete can be produced by ultra or nanoparticles that act as a filling agent in the intersectional zones of cement.

1 Nano-silica

UHPC technology that used silica fumes for better durability and strength, declined due to limited availability of silica fumes and high cost. Nano- silica mimics the action silica-fume and hence it is emerging as a newest technology in nano-process. Concrete with Nano-silica attains early strength when compared to concrete with silica fumes. With minimum dosage of superplasticizers, the workability of concrete increases when nano-silica is added. Addition of Nano-silica significantly increases the viscosity of UHPC by nucleation effect. Nano-silica in HSC not only increases the strength but also acts as cement replacement material where 20-30% of cement is replaced.

2 Nano-clay

Nano-clay is a nanoparticle of layered mineral silicate. Nano-clay is made of montmorillonite mineral deposit known to have platelet structure with average dimension of 1nm thick and 70-150nm wide. This unique structure poses qualities like stability, inter layer space, high hydration, swelling capacity and high chemical reactivity. Research on advantage and disadvantage of Nano-clay as construction material need to be explored. However, enhancement in Compressive and tensile strength of cement mortar having Nano- clay has been recorded.

3 Nano-tubes

Nano-composites can be developed by using Nano-tubes. Alumino-silicates are mixed with carbon Nano-tubes, which can produce strong and durable conductive firms. Nano-composite result in enhanced strength, stiffness and toughness without added weight. It has the capability to improve functionality, increased durability and reduced flammability. Carbon Nano-tube are allotropes of carbon with cylindrical nanostructure. Owing to unusual properties of CNT like extraordinary thermal conductivity, electrical and mechanical properties, CNT find its great application in structural materials as additives. Chemical bonds of these nanotubes are similar to graphite but are stronger than diamond and alkanes. The advantage of CNT in UHPC is flexibility and increased strength. The main reaction of CNT in UPHC is to improve tension and compression abilities. Steel reinforcement in UPHC can be replaced by nano- tubes which permits extra load, light weight sections and less reinforcement sections. Cost and time of construction is also reduced. Having less expertise and limited guidelines in Nano-tube preparation are the factors that reduces the its interest in UPHC mix.

C. Application of Nano-enhanced PCM in building

PCM- Phase Change Material

PCM is one of the most efficient technique for storing and releasing thermal energy in a relatively constant temperature with high storage density within the human's comfort zone.

PCM material = paraffin and hydrate salts

The PCM is used in the building with different methods , they can be integrated into the building material for use in building envelope such as glass, wallboard, walls, floor, roof, suspended sealings and windows as heating and cooling system for increasing the thermal mass .The properties of PCM can be improved by the addition of nano particles. The first study to investigate the effect of nano enhanced PCM for improving the thermal energy storage was carried out by Elgafy and Lafdi.

Compared to the use of pure PCM 8.3% more heat was charged in and 25.1% more heat was discharged from the nano enhanced PCM under 3 winter test and this can eliminate use of air conditioning system Nano PCM consisting of silver, gypsum and titanium was used as a Nano composite

D. Nano technology in glazed panel

Aerogel (smoked ice) is one of the best thermal insulating material that can be used for the glazed panel in the building. But the aerogel is fragile in nature, therefore it's composite with the other materials with higher toughness is needed. So, aerogel is reinforced with a glass fibre and coupled to breathable membrane made of poly propylene and these composite is called as an aeropan.

As compared to the conventional method of thermal insulation material, aeropan makes the glazed panel of reduced thickness(10mm), reduced energy loss and saving space in building applications.

This nanogel glazing could yield a saving of about 16% in the annual energy consumption.

E. Nanotechnology in steel structures:

Nanotechnology is improving the corrosion resistance in steel. The steel is now marketed as MMFX Steel which is five times corrosive resistance and three times strong than the conventional steel reinforcing bars.

The steel produced using MMFX'S technology has the unique nanoscale which is laminated lath structure resembling the plywood and it limits the primary corrosion initiator that causes the corrosion. Nanoflex (Sandvik Nano flex) is another nano material that has the impact on steel structure which increases the strength and durability.

Nanotechnology also play a major role in welding process. Welds and Heat Affected Zones (HAZ) can be brittle, failing without any warning when subjected to dynamic loading. This can be restricted by the addition of calcium and magnesium Nano particles increasing the weld toughness. Application of Vanadium and Molybdenum nanoparticles can improve the delayed fracture problems associated with high strength bolts.

F. Nanotechnology in wood

The significance of nanomaterial in wood is that it have the control over fibre-to-fibre bonding at a microscopic level and nanofibrillar bonding at the nanoscale. Nano catalysts that speeds up the chemical reaction inside the wood will make the wood multifunctional.

Nano sensors can easily identify the mold, decay, termites so that it can be rectified for the aesthetic appearance.

G. Nanotechnology in aggregate-cement paste bond:

The most vulnerable areas of concrete is the adhesion between the aggregate and the cement paste which is called as Interfacial Transition Zone(ITZ). The addition of pozzolanic material can improve the ITZ but it ends up in the bulk of the cement paste. The Nano particles like silica oxide, nonporous thin film(NPTFs) is added to the concrete as thin film on the aggregate surface has a high potential for improving the overall performance of the concrete.

The study shows that the mortar made with 0.0032 silica oxide-cement ratio deposited as a surface coating of just 1/3 of the total fine aggregates showed an average 35% increase in the overall compressive strength, flexural strength, tensile strength at early age along with decreased chloride penetrability.

H. Nanotechnology in coating:

Silicon resin house paint is widely used as it is water repellent and has self-cleaning property. The silicon nanomaterial forms the micro structured surface which makes the paint non wettable .These hydrophobic polymers can be added early on at the manufacturing stage or post production by means of molding, etching or applying a powder made from hydrophobic polymer or from nanoparticles. The impurities that is deposited on the tip of the micro structure of the paint is skimmed off by the drop of water that roll off from the surface. This can increase the durability and freshness of the paint.

Photocatalytic Nano titanium dioxide (TiO_2) is also used as the coating material. Titanium dioxide is hydrophilic due to its high surface energy, hence water does not form the drops on the surface. TiO_2 is reactive in nanoform. TiO_2 is photocatalytic i.e., in the presence of water, oxygen radicals are produced under UV light irradiation which in turn can decompose the organic materials such as fats, oils ,soot and plant materials. So the amount of dirt deposition is reduced which eliminates the often cleaning. It is very thin so it can be applied on the glass. Photocatalytic TiO_2 are added to concrete to red uce carbon monoxide and NO_x emission on roadways.

I. Nanoadditive fire retarders:

Unregulated dioxin-like polybrominated diphenyl ether (PBDE), in particular pentaBDE, commonly used as a fire retardant in furniture foam and plastic consumer goods has been banned in many European countries and nano additive fire retarder is finding its role in replacement of PBDE. Polymer nanocomposites filled with clay, CNTs, etc., possess improved flammability resistance while maintaining or improving mechanical properties. It reduces heat release rate during fire event by formation of surface char which insulates underlying material.

J. Cost:

The cost of most nanotechnology and equipment is relatively high. This is due to the novelty of the technology and the complexity of the equipment used for preparation and characterization of the materials(Mann 2006). However, costs have been shown to decrease over time and the expectations are that, as manufacturing technologies improve, these costs Vol. 19 [2014], Bund. T 4678 may further decrease. Whether the expected decrease will render the materials as run-of-the-mill construction engineering materials will have to be seen, and depends largely on the benefits rendered through the application of these materials. Current opinion is that in special cases, the materials will enable unique solutions to complicated problems that cause them to be cost effective, which will lead to large scale application of these specific technologies. In other cases, the traditional methods for treating the problem may still remain the most cost effective. It is a challenge to the construction engineer to solve real world transportation infrastructure problems and provide a facility to the general public at a reasonable cost.

II. CONCLUSION

Based on the review in the paper, nanotechnology creates a renewed world in the field of construction and building materials. These Nano-materials serve several requirements of civil engineers and contributes to the betterment of the environment. Use of Nano-materials in the construction field reduces pollution, produces corrosion free steel, production of insulators and coats. It also helps in minimisation of energy and producing cost efficient building materials. This passes the way for a number of promising developments that can potentially change the service life, cost of construction and infrastructure in an unimaginable rate in the future.

REFERENCES

[1] M.S.M. Norhasri et al./Construction and Building Materials 133 (2017) 91–97
[2] R.YuP.SpieszH.J.H.Brouwers Effect of Nano-silica on the hydration and microstructure development of Ultra-High Performance Concrete (UHPC) with a low binder amount. Constr. Build. Mater.65 (2014) 140-150
[3] Y. Qing et al., influence of nano-SiO2 addition on properties of hardened cement paste as compared with silica fume, Constr. Build. Mater. 21(3)(2007) 539-545
[4] Baetens,R.,B.P, Jelle and A.Gustaven,Phase change material for building applications a-state-of-the-art review .energy and building,2010
[5] Butala, V, and U.Strithi, Experimental investigation of PCM cold storage.Energy and building.
[6] Raj, V.A.A. and R. Velraj, Review on free cooling of buildings using phase change materials.
[7] Parameshvaran.R and Kalaiselvam.S. Energy conservative air conditioning system using silver nano based pcm.
[8] aspen aerogels, I., 2015. spaceloft aerogel insulation. Environmental product declaration according to ISO 14025 and EN 15805.
[9] Casini, M., 2016 advanced insulating materials, smart buildings.
[10] Mann, S., "nanotechnology and construcion"nanoforum report www.nanoforum.org
[11] ZhiGe, ZhiliGao, "Advancing and integrating construction education, research and practices. htttp://doi.org/10.3141/2142-05
[12] Jessica sanfilippo, Jose munose material science program
[13] Fujishima, A. and Zhang, X., 2006, Titanium dioxide photo catalysis: present situation and future approaches, *Comptes Rendus Chimie* 9 (5-6), 750-760.
[14] Leydecker, S., 2008, Nanomaterial in Architektur, Innenarchitektur und Design: Birkhäuser Verlag www.protectosil.com www.industrial-nanotech.com/main- page.html
[15] Dr. Joannie W. Chin, nanotechnology in building and construction.