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Nanomaterials For Sustainable Construction- A Review

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Abstract

Construction materials we see today is the result of a progression in science, technology and process. The extraordinary chemical and physical properties of nano materials enable novel applications ranging from strength, energy conservation, and antimicrobial properties to self-cleaning surfaces. The manufactured nano composites are being considered for various uses in the sustainable construction industries. To achieve environmentally responsible nanotechnology in construction, it is important to consider the lifecycle impacts of nanomaterials on the health of construction workers and dwellers, as well as unintended environmental effects at all stages of manufacturing, construction, use, demolition, and disposal. In this paper we review smart applications of nanomaterials that improve conventional construction, and summarize potential toxicological effects to human health and environment.

Keyword: Concrete, Nanoparticles, Green synthesis, Bioavailability Environment

1. Introduction:

The nano science was introduced by the famous physicist Richard Feynman in 1959, through his talk "There's Plenty of Room at the Bottom" [1]. The ideas put forward by Feynman passed unnoticed until 1974 when Norio Taniguchi introduced the word "nanotechnology" [2]. The benefits of using Nanoparticles (NPs) in construction materials are huge; the NPs can modify the physical, thermal, antimicrobial, self-cleaning and self-sensing, and self-healing and chemical properties of construction materials. NPs such as titanium dioxide, carbon nanotubes, and clay and aluminium dioxide are widely used in construction materials. NPs can be used in concrete binders to enhance performance. A range of nanoparticles can also be used for repair mortars or future self-healing applications. Others may be used for air purification or self-cleaning surfaces. Materials synthesized as water or germ repellents, ant mosses and moulds, can be selected for their properties by the construction industry. On the other hand, nanomaterials can be used in order to increase strength and durability of cement composites, pollution reduction, and corrosion-free steel products. They can be used for the production of thermal insulation materials with higher performance [3]. This review paper main focus on nanoparticles for energy savings, efficiency of buildings construction and their impact on human and environment.

2. Nanomaterials for Construction

The incorporation of nanoparticle technologies in the building industry is a further step towards green, efficient smart buildings. Nanoparticles can be used as binders in cement to enhance its properties, such as strength, durability, and workability shown in Table 1.

Table 1 Nanomaterials used for construction

Sr. No.	Nanomaterial	Unique Properties
1	Nano silica	Resistance to water penetration, workability, Fire resistance and mechanical strength [7] [19]
2	Nano clay	Enhancing the mechanical performance, resistance to chloride penetration and reducing permeability and shrinkage [8-9]
3	Carbon nanotubes and nanofibers	Extraordinary strength, electromechanical properties, high electrical and thermal conductivity [10-11]
4	Alumina	Changing microstructure of cement, Increasing the activating hydraulic and mechanical properties of cement [13]
5	Zirconium dioxide	Increasing the split tensile strength of self-compacting concrete [14]
6	Nanofibrous oxide	Improves compressive, tensile strength and flexural strength
7	Aerogel	Lightweight and thin plasterboard for interior insulation [16-18]
8	Titanium dioxide	high photocatalytic effectiveness, air purifier, waste water treatment cleaning, water disinfection and photo-induced hydrophilic coating with self-cleaning properties [20-21]
9	Microcapsules	Healing agent into the region that has been damaged, by capillary action [5]
10	Zinc oxide nanoparticles	Antibacterial activity, as gas sensor transparent conductor and catalyst [14-16]
11	Silver/Zinc oxide	Coating on wooden surfaces for hygienic requirements indoors [17]
12	Vanadium dioxide	Smart windows are capable of changing their throughput of visual light and solar radiation [25-26]
13	Quantum dots	Applied for solar energy generation in building sector contributing to further energy savings [27]
14	Copper, Vanadium and molybdenum NPs	Fatigue cracking of steels and anti-corrosion paints [28]
15	Silica and Alumina NPs	self-sterilizing surfaces, internal self-repair, and electronic lignocellulosic devices [29]
16	Cobalt Oxide/graphene	For energy storage applications in Li-ion Batteries [30]

Nanoparticles can also be used for repair mortars or future self-healing concrete and crack recovery. Nanostructured metal oxides can be used as photocatalytic products, antibacterial, self-cleaning and water or germ repellents. [2]. These are stronger composites, lighter structures, better properties of cementitious materials, energy efficiency, reduced thermal transfer, antibacterial surfaces, increased reflectivity of glass, energy generation, self-cleaning coatings and self-healing concrete [3]. The new nanostructures to develop a new multifunctional cement composite materials having high mechanical performances and durability [4-5]. Few of multifunctional nano materials could be cementitious materials with enhanced mechanical performance and durability, with a series of properties like self-cleaning, self-healing, crack control, and sensing [6].

Studies have also focused on the toxicity assessment of nanoparticles and the impact might have on the ecosystem and human health. The toxicity of the nanoparticles is associated with their miniscule dimensions and large surface area, comparable to their size. Their toxicity increases due to the reactivity of their large surface area and the ability to penetrate into cells. The toxicity of nanomaterials is may be due to oxidative stress, which damages lipids, DNA, carbohydrates, and proteins. The details of Health implications of nanoparticles to the human body shown in Table 2.

Table 2 Health implications of nanoparticles to the human being

Sr. No.	Nanoparticles	Risk to human being	References
1	AgNPs	Lungs, Liver, Brain, Carcinogenic, Vascular system, Reproductive organ, Inflammation in lungs, DNA damage, Immune system etc.	[31-34]
2	TiO_2 NPs	Metabolic Changes, Carcinogenic, Cell death	[35]
3	Fe_2O_3 NPs	Oxidative DNA Damage	[36]
4	CuO/ZnO	DNA Damage, Oxidative DNA Damage	[36]
5	ZnONPs	Cell proliferation	[37]
6	CNTs	Carcinogenic, Inflammation, oxidative stress	[38] [40]
7	SiO_2 NPs	Branch vascular Carcinogenic	[39] [41]

Conclusion

The review showed several issues related to nanomaterials for constructions, with the main focus on sustainable materials. The number research papers show the evolution Nanotechnology and Nanoscience it might give solutions to achieve zero energy building performance. Several nanomaterials like Titanium dioxide, Nanofibrous oxide, Alumina, Silver, Carbon nanotubes, Nanofibers, Quantum dots, Vanadium dioxide, Zinc oxide etc. are studied for their performance in the building construction. They may be incorporated in building matrices (like cement, steels, furniture and paints) for mechanical strength, elasticity and depollution or as coatings for self-cleaning, stone protection, or antibacterial usage. The rapid adoption of Nanotechnology into the construction industry is being slowed down high cost, awareness about toxicity of nanoparticles related to conventional materials. More research and practice efforts are needed to zero energy, reduce resource consumption, and avoid impacts on the human health and environment.

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