A Review on Advancements in Concrete Using Nanomaterials

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Abstract

The Construction business is the major consumer of energy sources of India. Among all the materials utilized in construction, concrete is the most generally used with the ingredients extracted from the nature, except cement, and have a major impact. The basic characteristics of concrete structures and materials can be altered by adding nano materials to increase mechanical properties and other parameters. A reduction in size of particles provides an exceptional surface area-to-volume ratio and changes within the surface chemistry, surface morphology, and surface energy of the particle. If cement with nano-size particles are manufactured and processed, there will be a variety of opportunities within the fields of ceramics of high strength composites and electronic applications. Furthermore, for the fine finishing and glazing purpose where strength is not a major criteria, nano materials in blend with cement is being used widely.

Keywords: Nanoparticles, Concrete, Nano SiO2, Nano TiO2, Nano Al2O3

I. INTRODUCTION

Engineering applications and advances within the construction and building materials fields are rare, utilizing engineering science in concrete on an advertisement scale remains restricted, with only a few results into marketable trade. The main advances have been in the nano science of building materials to increase in the data and understanding of basic phenomena in cement at the nano scale dealing with nano particles. Nano particles which are discussed here are nano SiO2, nano TiO2 and nano Al2O3 [1]. This paper reviews the main developments in the field of engineering science and nano science analysis in concrete.

II. SIGNIFICANT DEVELOPMENT OF NANOTECHNOLOGY

The concept of technology was argued by Feynman, this physicist said that nothing within the law of physics prevented us from arranging atoms the way you would like. He even described development pathway: Machines that might produce smaller machines suitable for creating yet smaller machines soon. The classic “top down” approach in 1974, Taniguchi introduced the term technology to explain exactitude manufacture of components with finishes and tolerances within the variation of zero. In 1981, Drexler recognized a replacement approach construction of materials and devices from the “bottom up” with each atom in designing location. The atomic force microscope (AFM) for working with nano conductive materials was also developed. Since then, a raft of related instruments now known collectively as scanning problem microscope (SPM) has been developed to analyze properties of nano structure, molecules and atoms on the surface. The potential to govern and point control matter on nano scale was incontestable, for the primary time [2]. Over the past decade, the focus on technology has broadened on the far side physics and exactitude engineering to incorporate “Almost any material or device that are structured on the nanometer scale to perform function or acquire characteristics which couldn’t rather be achieve

III. MATERIALS AND METHOD

A. Concrete:
Concrete is composed primarily of water, aggregate and cement. Alternatively, in engineering terms Water, Fine Aggregate, Coarse Aggregate and binder material Cement. It is composed of academic degree amorphous half, nanometer to micrometer size crystals, and certain water. Once these ingredients are mixed along, they type a fluid mass that is simply formed into form.
Over time, the cement forms a tough matrix that binds the remainder of the ingredients along into a sturdy stone-like material with several uses. The strength of concrete, mainly imparted by the chemical reaction between water and Cement called Hydration.

There are many factors, which makes the concrete versatile for construction industry like Mouldability, strength, workability, setting time, Coefficient of thermal expansion, modulus of elasticity, creep, shrinkage, durability, etc. Compressive strength of the concrete is one of the most important and useful properties of concrete. In most structural applications, concrete is primarily employed to resist compressive stresses. [16] The proportion of the ingredients, types of aggregates, properties of the ingredients, type of cement, etc. are the some common factors, which influence the strength. Strength of Concrete is widely expressed in the world in SI unit as MPa. At present in the world M5 to M150 (M indicates Mix & 5 or 150 Indicates Compressive Strength in Mega Pascal) and at present varieties of concrete depends upon the type of construction importance of construction are available in the universe viz. Lightweight concrete, High Performance Concrete, Self- Compacting concrete etc. [17] by adding admixtures.

One of the main bottlenecks which concrete industry faces at present is the over exploitation of natural resources as the ingredients of concrete, Sand, Coarse Aggregates is exploited from the nature and it leads to over exploitation and natural imbalance. Thus, a thought, of alternate materials in the form of composites, nano particles which do not change the chemical characteristics still gives good strength, have been playing in the research and development area for quite some time. Fig 1 below shows the thrust areas under discussion about concrete.

**FIG. 1**

**Nanoconcrete:**
Nanoconcrete is defined as a concrete created by hydraulic cement particles that area unit is five hundred nanometers because of the cementing agent. Currently cement particle sizes vary from a few nanometers to a most of about 100 small meters within the case of micro-cement the common particle size is reduced to five micrometers an order of magnitude reduction is required to turn out nano-cement [3].

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**IV. ADDITION OF NANO-SIZED AND NANO STRUCTURED MATERIALS:**
Nanosized particles have a high surface to volume ratio providing the potential for tremendous chemical reactivity. Much of the work so far with Nano particles has been with nano-silica (nano-SiO₂), nano-titanium dioxide (nano-TiO₂) and nano aluminum oxide (Al₂O₃). Only a limited number of investigations are going with the addition of nano sized and nano structured materials. Nano-particles will act as nuclei for cement phases to increase the hydration of cement due to its high reactivity, ability for the formation of both reinforcement and as filler, which reduces the porosity. [1].

**A. ADDITION OF NANO SiO₂:**
Addition of nano-silica (NS) in cement paste and in concrete can lead to completely different effects. One is size effect, i.e. primarily based on their particle nature, which makes it useful as filler material and second is the commerce pozzolanic activity(capability of reacting with calcium hydroxide and water)of the cluster compounds. There are many ways to synthesis nano silicon dioxide they are unit Sol-gel method, Electric-Arc-method, biological methodology, precipitation methodology and various production methodologies [4]. Nano SiO₂ may be directly prepared from bio waste like Rice, Husk, ash. Nano SiO₂ has an extremely amorphous nature. Nano silicon dioxide in concrete can increase the density, reduces porosity, and improves the bond between cement matrix and aggregates with higher compressive and flexural strength. Nano-SiO₂ have been found to boost
concrete workability and strength, to increase resistance to water penetration, and to assist control the leaching of calcium, which is closely related to various kinds of concrete degradation.

B. ADDITION OF NANO TiO₂:
The compressive-, split tensile- and flexural, strength, and workability and setting time of concrete is better when, partial replacement of cement with nano-phase TiO₂ particles. The decrease in workability and delays in setting time is found in the presence of nano particle blended concrete [7]. Based on the studies of the effect of limewater on flexural strength and water permeability of TiO₂ nano particles blended concrete. A vital accomplishment in flexural strength and water porosity of concrete with nano particle in the lime water set was ascertained, however, there was no extended improvement in compressive strength [8, 9].

C. ADDITION OF NANO Al₂O₃:
Addition of nano Al₂O₃ creates strength of the materials of concrete. By adding nano Al₂O₃, a major accomplishment in high compressive strength was established. By adding of Al₂O₃ nano particles, it absolutely was noted that the strength of the concrete was redoubled because of the strengthening of gel for nano particle mixed H₂O than H₂O while not nano particle. The impact of nano Al₂O₃ on coefficient of elasticity and compressive strength of the cement composites was ascertained. The role of nano particles as a fine combination is studied through SEM and EDS study stating that the nano Al₂O₃ fill the ITZ of cement-sand and some capillary in the matrix and thus the elastic modulus and compressive strength of mortars were redoubled. But, no vital improvement in compressive strength was detected because of the scant filling of pores within the cement matrix beneath experiment conditions.

V. APPLICATIONS

A. Nanotechnologies for Construction:
Nanotechnology is applied to paints to assure the corrosion protection under insulation since it's hydrophobic and repels water from the metal pipe and might also protect the metal from attack of salt. Other applications refer to coatings that have self healing capabilities through a method of “self assembly”. In addition to the self-cleaning coatings mentioned higher than for glazing, the remarkable properties of TiO₂ nano particles are put to use as a coating material on roadways in tests round the world [12].

B. Nanotechnologies for fire Protection:
A coating produced by a spray-on building material method usually provides fire resistance of steel structures. Nano-cement (made of nano sized particles) has the potential to make a troublesome, durable, heat coatings. This can be achieved by the blending of carbon nanotubes with the cementitious material to fabricate fiber composites which will inherit a number of the outstanding properties of the nanotubes [13].

VI. FUTURE DEVELOPMENT:
Vast progress in concrete science is predicted in returning years by the variety of recent data generated from the chop-chop growing field of applied science[2]. Development of the following concrete-related nano materials are on the way:
- Catalysts for the low-temperature synthesis of clinker and accelerated hydration of conventional cements.
- Grinding aids for superfine grinding and mechano-chemical activation of cements.
- Binders with enhanced/nano engineered internal bond between the hydration products.
- Binders changed by nano-sized compound particles and their emotions, or polymeric nano films.
- Bio-materials (including those imitating the structure and behavior of mollusc shells).
- Next-generation super plasticizers for “total workability control” and supreme water reduction; Binders with controlled internal wet offer to avoid/reduce micro-cracking.
- Cement-based materials with designing nano- and micro- structures exhibiting supreme durability. Eco-binders modified by nano particles and produced with substantially reduced volumes of Portland cement component (10-15%).
- Self-healing materials and repair technologies exploitation nanotubes and chemical admixtures. Materials with self-cleaning/air-purifying options primarily based on photocatalyst technology [14].

VII. CONCLUSION
The present paper reviews the present state of applied science in the concrete and up to date key advances. The potential of applied science to boost the performance of concrete and to steer to the event of novel, property, advanced cement based composites with distinctive mechanical, thermal, and electrical properties is promising and many new opportunities are
expected to rise in the coming years. 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. The introduction of these novel materials into the public sphere through civil infrastructure can necessitate associate analysis and understanding of the impact that they will wear the surroundings and human health [15].

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