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Review of the Use of Nanotechnology in Construction Industry

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Abstract:- In Civil Engineering, vast improvement has been achieved through the production of materials with new purposes or by refining the performance of existing ones, today

Nanotechnology is widely considered as one of the21st century's important technologies, and its economic importance is gradually on the rise. In architecture and the construction industry it has possibilities that are already usable today, Such possibility can already be seen today through many current applications related for instance to surface coatings, self-cleaning capacity, and fire resistance, and others[1].

Nanotechnology is an extremely wide-ranging term. Most commonly, nanotechnology is defined as "…the understanding, control, and restructuring of matter on the order of nanometers i.e., less than 100 nm" (the definition of which varies from field to field.) to create materials with basically new properties and functions" [2].There are two main types of approaches to nanotechnology: The "top-down" approach and the "bottom-up" approach. The "top-down" approach involves taking larger structures that are either reduced down in size until they reach the Nano-scale, or are deconstructed into their composite parts. On the other hand, the "bottom-up" approach is where materials are constructed from the atomic or molecular components. So we can define Nano technology as:

The science of engineering that deals with particles which are less than 100 nm in size. It is the study of manipulating matter on molecular and atomic scale. In recent years, nanotechnology showed its prospective in the field of biomedical [3,4].Electronics, robotics. In civil engineering and construction, the nanotechnology is applied in (i)concrete for reducing segregation in self-compacted concrete[5]., (ii) the use of copper Nano-particles in low carbon HPS is remarkable[6]., (iii) the use of Nano sensors in construction phase to know the early age properties of concrete is very useful, [7]and (iv) its use in water purification system by replacing the use of granulated particles of carbon in filtration with purifiers like Nano Ceram-Pac (NCP) [8]. The present paper reviews the use of nanotechnology in many different construction fields.

Keywords:-Nanotechnology, carbon nanotubes (CNT's), Self Compacting Concrete (SCC),Strengthened Concrete

One of the most common and beneficial uses of nanotechnology in terms of civil engineering, is the use of it in concrete. Concrete "is a nanostructure, multi-phase, composite material that ages over time. It is composed of an amorphous phase, nanometer to micrometer size crystals, and bound water," It is used in almost all construction, from roads, to bridges, to buildings. Concrete can be modified in numerous ways; one of which is to add nanoparticles to

as reported in [9], much analysis of concrete is being done at the Nano-level in order to understand its structure using the various techniques developed for study at that scale such as Atomic Force Microscopy (AFM), Scanning Electron Microscopy (SEM) and Focused Ion Beam (FIB).The understanding of the structure and behavior of concrete at the fundamental level is an important and very appropriate use of nanotechnology.

One of the advancements made by the study of concrete at the nano scale is that particle packing in concrete can be improved by using Nano-silica which leads to a densification of the micro and nanostructure resulting in improved mechanical properties [10].Nano-silica addition to cement based materials can also control the degradation of the fundamental C-S-H (calcium-silicate hydrate) reaction of concrete caused by calcium leaching in water as well as block water penetration and therefore lead to improvements in durability. Related to improved particle packing, high energy milling of ordinary Portland cement (OPC) clinker and standard sand, produces a greater particle size diminution with respect to conventional OPC and, as a result, the compressive strength of the refined material is also 3 to 6 times higher (at different ages).Another type of nano particle added to concrete to improve its properties is titanium dioxide (TiO_2) [11]. TiO_2 is a white pigment and can be used as an excellent reflective coating. Since TiO_2 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 [12]. Additionally, it is hydrophilic and therefore gives self-cleaning properties tothe applied surfaces. In this process rain water is attracted to the surface and forms sheets which collect the pollutants and dirt particles previously broken down and washes them off. The resulting concrete has a white color that retains its whiteness very effectively [13].

The carbon nanotubes (CNT's).

The carbon nanotubes (CNT's) has an excellent properties as its high conductivity (being more than copper), elastic deformability, strength (being stronger than steel), surface chemistry, high stability are some of the properties that CNT's provide due to their structure and topology [14].

Increasing the strength for a longer duration of time and prolonging life along with givingboost to the compressive strength and contributing to the tensile strength by improving the flexural strength is reported from earlier research work, when CNT's are mixed withAsphalt and concrete. A reduction in the emission of greenhouse gases, energy consumption, maintenance costs, resistance to moisture are some of the advantages of using asphalt containing nanoparticles.

Research is being carried out to investigate the benefits of adding carbon Nano tubes CNT's to concrete. The addition of small amounts (1% wt) of CNT's can improve the mechanical properties of samples consisting of the main Portland cement phase and water .Oxidized multi-walled nanotubes (MWNT's) show the best improvements both in compressive strength (+25 N/mm2) and flexural strength (+8 N/mm2) compared to the reference samples without the reinforcement. However, two problems with the addition of carbon nanotubes to any material are the clumping together of the tubes and the lack of cohesion between them and the matrix bulk material. Additional work is needed in order to establish the optimum values of carbon nanotubes and dispersing agents in the mix design parameters. In addition, the cost of adding CNT's to concrete may be prohibitive at the moment.

Currently, the use of nano materials in construction is reduced, mainly for the following reasons: the lack of knowledge concerning the suitable nano materials for construction and their behavior; the lack of specific standards for design and execution of the construction elements using nonmaterial's; the reduced offer of nano products; the lack of detailed information regarding the nano products content; high costs; the unknown of health risks associated with nano material [15, 16]

Self Compacting Concrete (SCC)

Balaguru [17] stated that Self Compacting Concrete (SCC) is one that does not need vibration in order to level off and achieve consolidation. This represents a significant advance in the reduction of the energy needed to build concrete structures and is therefore a sustainability issue. In addition SCC can offer benefits of up to 50% in labor costs[18]., due to it being poured up to 80% faster and having reduced wear and tear on formwork. The material behaves like a thick fluid and is made possible by the use of poly carboxylates (a material similar to plastic developed using nanotechnology). Self-Compacting Concrete (SCC) is a new type ofconcrete, which has generated tremendous interest, since its initial development in Japan by Okamurain the late 1980s in order to reach durable concrete structures. Since that time; Japanese contractorshave used SCC in different applications. In contrast with the Japan, research in Europe the advantages of SCC offers many benefits to the construction practice: the elimination of the compaction work results in reduced costs of placement, equipment needed on construction, shortening of the construction time and improved quality control [19]

Fiber wrapping of concrete is quite common today for increasing the strength of preexisting concrete structural elements. Advancement in the procedure involves the use of a fiber sheet (matrix) containing Nano-silica particles and hardeners. These nanoparticles penetrate and close small cracks on the concrete surface and, in strengthening applications, the matrices form a strong bond between the surface of the concrete and the fiber reinforcement [20].

Benefits of using Nano materials in Concrete:

Strengthened Concrete:

Carbon Nanotubes CNTsare added to the concrete mixture. Carbon Nanotubes are cylindrical with a diameter of 1 nanometer are theoretically 100 times as strong as steel but have only tested to be 8 times stronger[19,20] They are 1/6 the density of steel.

- Very high thermal conductivity along the tube axis
- The finished product has 1% CNT's to the 99% standard concrete.
- Can handle an additional 25 N/mm.

Strengthened concrete has 500% the tensile strength of normal concrete.

Self-Healing concrete [21, 22].
•Nano particles only allow small cracks to form.
•The particles mend themselves when they encounter water.
•The hydrogen in the water helps the particles form the broken hydrogen bonds.
•Cracks will repair themselves when water is added

Nanoclay-modified asphalt materials [23, 24, 25].

In the United States, transportation infrastructure investments account for 7% of the Gross Domestic Product (GDP) according to the National Asphalt Pavement Association [26,27]. Over 550 million tons of hot-mix asphalt (HMA) is produced annually for construction projects. Increasing traffic loads and traffic volume, combined with the rising cost of asphalt, have led to an urgent need to improve the durability, safety and efficiency of asphalt pavementsthrough asphalt modification Ideal asphalt it should possess both: (1) high relative stiffness at high service temperatures (summer) to reduce rutting and shoving and; (2) increased adhesion between asphalt and aggregate in the presence of moisture to reduce stripping. The project team conducted preliminary tests, blending small percentagesofnanoclay-composites into virgin asphalt with the hope of producing binder that is less susceptible to high-temperature rutting and low-temperature cracking. The motivation is to significantly reduce the temperature sensitivity of the binder at service temperatures while maintaining workability at construction temperatures.Nano-modified asphalt may potentially improve the rutting, crack and fatigue resistance of asphalt mixtures nanoclays can be
Effectively used as a modifier to improve the mechanical properties of asphalt binders [28,29,30].

CONCLUSION:

This paper meant to highlight some of the work in the field of construction industry new innovations of using nonmaterial's, this industry can benefit from the enormous researches in this field:
Nanotechnology is a rapidly growing area of exploration where innovative properties of materials manufacturedon the nanoscale can be developed for the benefit of construction infrastructure.

A number of encouraging developments exist that canpossibly change the service life and life-cycle costof construction infrastructure.
Additional work is needed in order to establish the optimum values of carbon nanotubes that added to concrete And dispersing agents in the mix design parameters.
There is a great need to Work on developing standards for design and execution of the construction elements using nonmaterials.

The exposure and impact of nonmaterial's on plant life and organisms need more Investigation Through the implementation of responsible use of nonmaterial's and broad studies of nonmaterial interaction with the environment, such risks can be moderated or avoided, thus leaving the research community, industry and end users to advantage from the use of nanotechnology[31].

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