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# NANO TECHNOLOGY: APPROACH AND APPLICATION IN CONSTRUCTION TECHNOLOGY

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## ABSTRACT

Nanotechnology is finding its place in almost all spheres of engineering and sciences. Traditionally, nanotechnology has been concerned with developments in fields like microelectronics, medicine and materials sciences .The major leaps in application is in civil engineering also through development of new dimension building construction materials. The nano particles, nano sensors and other thrust area have marked increase in strength and are reducing the dead weight. In initial stages as applicable to any incoming technology it is not cost effective. Lack of mind set for adaption of new things is posing some difficulty in its incorporation. Merits of its being environment friendly is yet to be proved.

***Keywords-*** *Nanoparticles, strength, building materials, nanotubes, nanosensors, nano steel, nanoc onstruction.*

## I. INTRODUCTION

Nanotechnology is the current dominating field in technology, physical sciences and life sciences and organisms which ranges in the length comparable in the range of 0.01 micro meters to 100 nano meter range. Nano means 1 billionth of a meter. Application of these particles and technology is covering almost all sphere of life of nature which includes the environment also. Nanotechnology is a field that is dominated by developments in basic physics and chemistry research . Here phenomenon on atomic and molecular level is used to provide materials and structures to perform tasks which are not possible now with existing materials. The revolution and evolution of technology and instrumentation as well as techniques and the technology which relates to scientific areas such as physics and chemistry are making innovation and research on nanotechnology aggressive and evolutional for use in new streams .The current scientific temper across the globe is also amply funding. The developed nations are taking lead in it. The U.S. National Nanotechnology Initiative (NNI) alone has marked its budget of exceeding $1 billion each year since 2008. It is other aspect that main focus of research is mainly on moving forward with motivation on immediate profit generating returns in high value commercial products [3]. The various studies reveals that innovations and initiatives in the construction field using this nanotechnology has made it to rank 8 th out of 10 top applications considered. It is likely that it will have great impact on third world and developing world countries also .

Development of nano materials and nano sciences development in nanotechnology covers the entire spectrum i.e. from design to construction to its utilization of functional structures with at least one characteristic dimension measured in nanometers for applicability in nano senses [15]. The area or domain of nanotechnology in every sphere has developed in major leaps during the past decade. The developments have mainly been driven by factors such as intensive dedicated initiatives in the field by leading national agencies across the countries, improvements in characterization equipments, new development understanding and codification of aspects in the areas of applied chemistry and physics particularly for the matters in the nano-scale. This Nano-scale science can be broadly divided into three areas keeping in mind their typical applications in nano-electronics and life sciences & energy. The areas can be listed as

Nano-structures,
Nano-fabrication and
Nano-characterization. [15]

Current piece of work is with the aim to examine the potential areas where nanotechnology can benefit construction engineering. The details, information, relevant data and observations have been collected from currently available literature on internet and print media literatures with purpose of brining out innovative approaches and modification and gain of strength gains in current direction among the nanotechnology development areas where the construction process would immediately harness nanotechnology, by specifying clear recommendations from the researcher groups across globe.

## II. APPLICATION OF NANOTECHNOLOGY IN CONSTRUCTION

It is evident that the Nanotechnology used / generated /promulgated products have many unique characteristics so it is advisable to for going in for design and construction processes in many areas using this. The uniqueness and features we can look through nano technology include products suited for or having Lighter structure; Stronger structural composites which is best suited in case of bridges, supported other civil structures etc ; Low and long lasting maintenance coating ; Improving and strengthening pipe joining materials and techniques ; Better advanced quick setting properties of

cementations materials ; Water repellent properties , non clay filled polymers :self disinfecting surfaces: Reduction of thermal transfer rate of fire retardant and insulation for firefighting; Increasing the sound absorption of acoustic absorber for better acoustics; Increasing the reflectivity of glass for better communication: UV light protector; nano sized sensors; Solar cells systems , etc.
There are large numbers of other applications of nanotechnology in construction engineering/industry reported these days. Some of these applications are listed and examined in brief. The details are as follows:-

***A. Concrete as Building Material***

A most common and widely used construction material is cement with varying additives for getting different types of results. The additives are often on nano scale materials. Technological additions and mixes for getting varied results are leading to rapid development for new experimental techniques. These techniques are making are paving ways for study of properties of cementitious materials at varied micro/nano-scale. Recent studies have been conducted to study the quick setting option of hydration process, alkali-silicate reaction (ASR), and fly ash reactivity using nanotechnology [6]. The better understanding of the structure and behavior of concrete at micro/nano-scale could help to improve concrete properties and prevent the illness, such as ASR.
Addition of nanoscale materials into cement could improve its performance has been reported. Research by Li et al came to conclusion that mixing of nano-SiO2 in conventional cement can increase strength in compressive uses. Containment of increased volume of fly ashes in early stages of setting improves pore size distribution by filling the pores by nano scale particles between large fly ash and cement particles. Another research came out with finding that use of amorphous nanosilica in the dispersion/slurry improves segregation resistance for self-compacting concrete [8]. It has also been reported that adding to 1 % amount by weight of carbon nanotube increases compressive and flexural strength both [7].
To address the common problem of cracking in the cement concrete in structures due to various reasons adding polymers which include a microencapsulated healing agent and a catalytic chemical trigger can provide relief is a major concern for many structures.[8]. Properties of release of healing agents by the used polymers in the cracks with the catalyst in the cracks are utilized. Class of self healing polymer can be exclusively used and applied to take care of possible micro cracking in bridge piers and columns even at a later stage when it appears through the relatively less cost effective epoxy injection in the affected areas.

***B. Structural Composites Materials***

Steel is a major construction material. Properties like strength, corrosion resistance, weld ability and ease of reinforcementing in concrete structure to offer compressive strength are most suitable for civil design and construction. Pioneer FHWA with famous American Iron and Steel Institute and defense took up project in 1992 itself to develop low carbon, high performance steel (HPS) for bridges [10]. New developed steel exhibited higher corrosion-resistance, better weld ability with infusion of copper nano-particles on the boundaries of steel grains. Sandvik Nanoflex Materials Technology developed new Varity of ultra high strength stainless steel named Sandvik Nanoflex TM which offered very good formability and relatively good surface finish which makes it more suitable for applications requiring lightweight and rigid designs. Good corrosion & wear resistance further enables merit of keeping life-cycle cost at further low level making it cost effective. MMFX2, nanostructure modified steel, product of MMFX Steel Corp when compared with available conventional steel has fundamentally altogether different microstructure like laminated lath structure which resembles like available plywood. This unique structure of MMFX2 steel provides three times stronger strength, enhanced ductility, greater toughness, and marked corrosion resistance with only disadvantage that this costs more which limits its use to structures of limited affordable high risk environments only.

***C. Coating and Water Proofing Materials***

Basic purpose of coating is to cover a surface for protection and providing strength or to provide a system which does away the undesired elements. The coating materials are certain chemicals derived from the nano particles. In coating chemical vapor deposition, dip, meniscus, spray and plasma techniques are used for providing a surface of desired protective functional properties.
These are incorporating certain nanoparticles which include nanopolymers and nano layers specially designed and developed for certain purpose. Best examples of for such materials are the TiO2 which is used to coat glazing mainly because of its sterilizing & anti fouling properties. ThisTiO2 has capacity to break down & disintegrate organic dirt through powerful catalytic reaction and since it is hydrophilic i.e. it allows water to spread very fast evenly over the entire surface and as per slope the dirt gets washed away which otherwise would have created voids in the cement and has caused to develop cracks in the surface. Coating for attaining the anti-fraffiti, thermal control, energy sawing, antireflection by special materials also can be achieved.
Waterproofing is a treatment, which makes the structure and material impervious to water which addresses and prevents loss of structural strength of concrete building materials, particularly due to ASR (alkali silica reaction), acid rain, sulphate attacked. It also prevents chloride penetration which can result in corrosion of the reinforced steel bars.

Normally building materials are very porous and attract water because of the hydrophilic nature causing most of the building material easily wet and absorb water in the pores. The size of the water molecule is 0.18 nm (i.e. 0.00018 microns).The size of the pores in most of the building materials, ranges from 5 to 200 nm whereas size of most of the pollutants like acids, chlorides & sulphates are in the range of 1 to 2 nm. Even with compact dense concrete and stones, pore sizes are very larger than water which allows water in the building material.
The essential requirements of a good waterproofing materials are :-
High Resistance it can impart to water absorption.
Prevention of water soluble salts including chloride salts.
Long-term stability in alkaline environment.
Penetration of waterproofing treatment to a measurable depth.
Non-staining of treated surface areas.
Low environmental and health risk.
UV stability of over 20years.
There are two classes of waterproofing products: a) Film Formers & b)Penetrates Film Formers.

***D. Use of Nanosensors and advantages***

NEMS and MEMS i.e. Nano electro mechanical system (NEMS) and micro electro mechanical system (MEMS) sensors have been developed and used in construction for monitoring and controlling environmental conditions of the employed construction materials and structures performance and life detoriation. These sensors which can be embedded in the structures during construction process come in the dimension of $10^{-9}$ m to $10^{-5}$ m range . The $10^{-9}$ m to $10^{-5}$ m range comes in the nano and micro scales. Low cost piezo-ceramic-based multi-functional devices which can be termed as smart aggregates cab be placed to monitor concrete properties which range from moisture, temperature, relative humidity to age related strength detoriation or development. The sensors are also capable to monitor concrete corrosion, cracking and monitoring structure health. This smart disclosed system can further monitor internal stresses, cracks and other physical forces in the structures during entire life span of structure. The detoriation and early failure can be easily detected by these sensors.

## III. FUTURE CHALLENGE AND DIRECTION

Any change in existing technology always invites number if adjustments and new drawbacks with the changes perceptions and poses new challenges and application with varied dimensions and directions. In other words developing and changing newer technologies many number of challenges can be seen as existing during the initial and initiation of such application of this so called nanotechnology into reality and existence. Being realistic to identify and plan for overcoming new limitations and challenges inherited with inherent technologies in this process is bound to come. To deal with all possible challenges is not possible but glism in form of briefs of selected challenges and limitations affecting application of nanotechnology in construction engineering can be listed and dealt . The most important challenges can be listed as
Challenges in Fabrication,
Challenges in Health,
Challenges of Environment
Challenges in terms of Cost
Challenges for Green Building concept

***A. Challenges of Fabrication***

Current nanotechnology efforts are focused on the fabrication with help of nano materials and nano science application. The development is aimed at focusing on very minute small quantities of nano-materials application removing he existing ones with aim at increased strength and miniaturization for typical construction infrastructure. Basic solution to this is on focusing on the nano materials acting as catalyzer which will reduce amount of nano material required substantially to obtain a major improvement in terms of benefits. This can be achieved by reduction of dimensions of cement, where a substantial reported improvement in strength can be best obtained through the large scale milling of cement with finer form compared to traditional form irrespective of fact that these nano materials alone cannot be used in first go .

***B. Health***

There is no through study of he use of nano technology on health. Perception is that the signals originating from the nano technology adversely affects the human health system. The workers involved in the construction works might get affected by the minute particles nano tubes and they amy get affected for lung related problems. In other words, the

derived dust and related systems may be responsible for health hazards for the workers involved or the passive persons who live nearby and this may have adverse affect on construction business.

### *C. Environment*

The effect of various developed nano-materials and nano particles used in the construction purposes on natural environment study is a live topic for researchers and environmentalists. Investigations under development in the nano scale are differently different from that of micro and macro level materials so obviously the associated problems will be also different. Research works in this regard are indicative for minimal potential effects in this arena . The problem of dust particles of nano dimensions and its leaching to groundwater is concern to environment. We can see that nano-technology is developing as double-edged sword to the construction industry. Extended intensive research and aimed practical practice efforts are required and needed with smart design and planning for construction projects for sustainable development is need of hour for saving energy, reduction of resource usage and efforts to avoid damages to environment.

### *D. Cost*

The costs involved in developed nanotechnology materials and equipment is bound to be high at initial stage, hence initial cost hike will be challenge. The main cause for this is the novelty of the technology and complexity of equipment required for preparation and characterization of these nano materials. With increased time and more and more adaptability will result is declining cost of development of such nano materials and this is showing decline in cost involvement. The gaining strength, increased options of dust free construction and added advantages which will reduce the maintenance and operation cost will further reduce the cost involved and the cost effective approach will be evident. The research and adequate data analysis and proper handling together with proper handling and reduction in transportation and use can further reduce the cost and make the new approach more effective.

### *E. Nano technology and green building*

Nanotechnology, manipulation of matter at molecular scale is responsible for bringing new materials, new possibilities and new avenues for electronics, medicine, energy and aeronautics and even construction industries. Enhanced ability to design new nano scale materials from grass root level is bound to have impact on building construction also. New materials, products and appliances based on nanotechnology are coming and getting developed for building insulation, coatings, dust removal, stress and compression sharing and solar technologies will lead to green buildings. Current works will soon result in new products for lighting, structures and energy that will save resources and cause less detoriation to existing environment. Till date study reveals that nanotechnology has already brought to market self-cleaning windows, smog-eating concrete and many other required and environment friendly advances. Work for illuminating walls that change colour with the flip of a switch, nano-composites as thin as glass of very strong strength capable of supporting entire buildings, and photosynthetic surfaces making any building facade a source of free energy is underway for green building.

## IV. CONCLUSIONS

The facts discussed above clearly indicates that :

• Nanotechnology is invading civil engineering equally through its novel properties of materials manufactured on the nanoscale which is offering increased strength in structures.

Nano technology can be utilized for the benefit of environment friendly ecologically balanced construction infrastructure.

• Numerous promising developments exist that can potentially change the service life and life-cycle cost of construction infrastructure and mark increased life span of overall structure.

• Further focused and directed research into nanotechnology for construction infrastructure should be carried out extensively to ensure potential benefits of this technology for providing increased longer life and economical transport infrastructure fro sustained development with eye on conservation of environment and ecology.

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