

# **Review on Potential of Nanotechnology & its application Opportunities in Civil Engineering Domain for Sustainable and Environmental Friendly Infrastructure Development for Economical Growth**

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**ABSTRACT:** Nanotechnology is considered as one of the dynamic research on the planet in modern way of life. At nanoscale property of the material is spectacularly pretentious, controlled to formulate novel material with innovative and unique properties. At the same time, Infrastructure development is the backbone for economical enlargement of every nation, particularly like India, whose economy is growing very fast in 21st century to become developed nation. Infrastructure development facilities are one of the major consumers of building materials and natural resources. It consumes almost 40% of materials and resources. In this brisk development phase, sustainable and environmental friendly infrastructure is the prime need for safety and reduces environmental degradation as a result of emanation of green house gases by amalgamation of nanotechnology in civil engineering sector. Nanotechnology can be applied in construction and design enhancement and innovation. Thus nanotechnology can drastically solve the problems of civil engineering field.

**KEY WORDS:** Nanotechnology, Civil Engineering, Sustainability, Environmental Pollution, Eco friendly materials

## I. INTRODUCTION

### **Nanotechnology: A new path in the field of Science and Technology**

Nanotechnology is re-manufacturing of materials and expansion of science and technology that was in way of life and development from many years [1] in the different fields like medicine, environmental, energy, communication and information etc. [2]. But, now a day, nanotechnology and nanoscience is gaining popularity in the field of civil engineering due to its ability to study matter at atomic and molecular scale, study of complex structure of material at nano level [3], and various laws of physics can come into picture like quantum physics etc [4]. Nanotechnology is a field that is conquered by enhancement in basic physics and chemistry research, where the occurrence on atomic and molecular levels are used to provide materials and structures that function that are not achievable using the materials in their typical macroscopic form. One of the vital aspects of nanotechnology is, as particle become nano sized proportion

# International Journal of Innovative Research in Science, Engineering and Technology

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Vol. 6, Issue 6, June 2017

of atom on the surface increases relatively those inside and this helps to change the property of material [5]. In Nanotechnology the size of the particles span between 1 to 100 nanometre [6], at this scale, property of the materials are significantly altered [7] and this leads to new material with improved mechanical properties such as strength, durability, sustainability, etc[8].

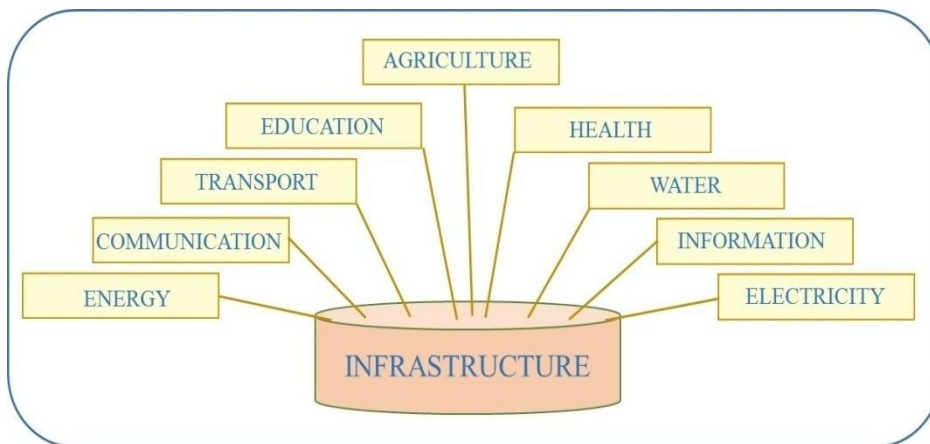


Fig.1. Components of Infrastructure

The fact is that in nanotechnology it is not only to play or work with particle at nano scale, it is more beyond that. Nanotechnology provides space to researcher to exploit the unique property of material such as- mechanical, physical, optical and chemical that taking place at nano level naturally [9]. Nanotechnology used two types of approaches [1] top down approach and [2] bottom up approach. In top down approach nano entity is manufactured exclusive of atomic level control and in bottom up approach nano entity is manufacture using atomic components and using the principal of atomic recollection [6]. Economical aspect of nanotechnology is also unusual; it is estimated that business related to product and services will reach to more than a few hundred billion euros at the end of this century. Countries are preparing national nanotechnology strategies and plans and started implementation on same so that when in future application of nanotechnology have the noteworthy influence on world's wealth country can take the utmost advantages by application of nanotechnology[10]

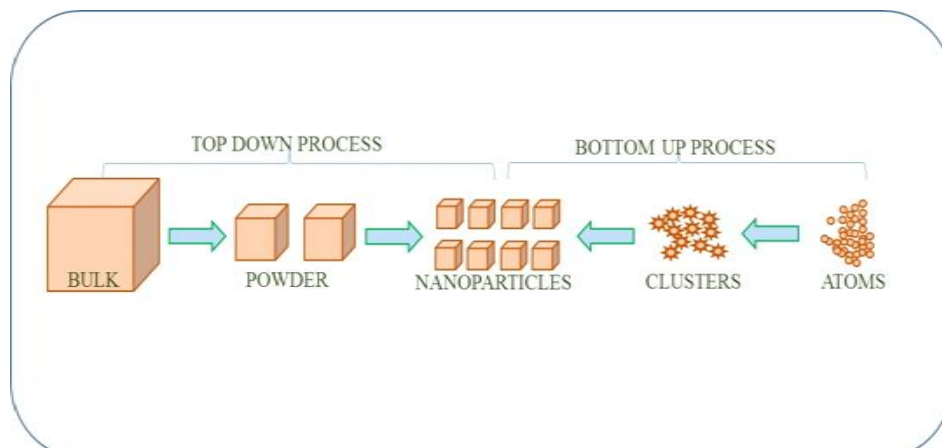


Fig.2. Top Down and Bottom up Approach for Nanotechnology

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Vol. 6, Issue 6, June 2017

## II. ROLE AND IMPORTANCE OF INFRASTRUCTURE DEVELOPMENT IN ENHANCEMENT OF ECONOMY OF COUNTRY

Infrastructure facilities are the essential for the economical development of any country. Transport, health, energy, water, telecommunications, housing, and educational facilities have become part and parcel of human existence. Without these facilities it is knotty to make believe a modern world [11]. The importance of infrastructure for prolonged economic development is highly praised. High operational costs occurring from ineffective and scarce inefficient infrastructure facilities can foil the economy from realising its full growth potential regardless of the progress on other fronts [12]. Infrastructure facilities are under pressure due to recent globalization, industrial development, population growth, etc at global level [13]. Infrastructure development works as fuel to ignite growth of the country's economy. It will enhance a country's production, as a result making firms more competitive and enhance a region's economy. Not only does infrastructure in itself enhance the efficiency of production, transportation, and communication, but it also helps provide economic encouragement to public and private sector participants. The easy, user friendly and excellence of infrastructure in a country help to influence national firms' investment decisions and determines the region's attractiveness to foreign investors [13]. If infrastructure development is poor and insufficient in the country it will obstruct economical growth and competitiveness at global level [14]. Inter relation between infrastructure development and economical growth is complex and multiple in nature. It effects the production as well as consumption directly but it also creates many direct and indirect externalities, and involves huge surge of expenditure thereby providing additional employment opportunity in country [15]. Increase in the investment and employment pushes labour and employment rates thus in true increase in the income of the people, due to enhancement in economical level, purchasing power of people also increases lead to more demand of goods and positive impact on production segment and economical enlargement of country. Thus, population income level and gross domestic production (GDP) are the two measure of economical development of any country [15].

As per the report, Indian government has concluded that economical growth has been hampered due to insufficient infrastructure facilities. Finance Minister of India has estimated that due to insufficient infrastructure resources, per year growth was hampered by 1.5 % to 2.0% [13]. Development of Agriculture and industries in a straight line has an effect on the country's economy. Agriculture and industrial sector both required infrastructure facilities in terms of – electricity, transportation, credits, telecommunication, machinery, marketing, equipments etc. If adequate infrastructure resources exists the province, efficient economical growth of the region takes place and per capita income and purchasing power of people will increase shapely [11].

## III. REQUIREMENT OF SUSTAINABLE AND ENVIRONMENTAL FRIENDLY INFRASTRUCTURE DEVELOPMENT

Infrastructure amenities are very imperative in favour of the economical, social, cultural, environmental advancement of any country [16]. Sustainable development means development that fulfils the requirement of the present without negotiation the capability of forthcoming generations to meet their own needs. Sustainable world we do not continue the accelerating depletion of non renewable resources, nor the consumption of renewable resources faster than the environment can regenerate them [17]. Sustainable and efficient infrastructure facilities are the key to any nation to compete at global level and connecting integrated cities for better services to citizens. Also improves the quality of life of human at the same time as provision of energy resources taking into account natural environment and climate change. As per United Nation report cities consumes three quarter of natural resources, it is estimated that population in city is going to reach 70% up to 2050. In this perspective, new infrastructure facilities are required to avoid ecumenical and environmental deduction for the future generation [18]. Changing global environment creating awareness regarding sustainable infrastructure development that uses natural resources effectively and having minimum impact on the environment and acknowledge uses to sustain its significance in future [19].

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Vol. 6, Issue 6, June 2017

Infrastructure is a necessary part of the development allied with a growing human population, industrial development, urbanization, but it can also have detrimental impacts on the ecosystem [20]. Environment is the most important key term economically, socially, politically, scientifically, and technically for everybody living on planet in the modern world [21]. Infrastructure development is required to support new ways of working and living for a growing population and to enhance economic development and a switch over to a low carbon economy. New infrastructure development can lead to considerable benefits, including the chance to build in such a way as to meet the challenges posed by climate change and to enhance sustainability, however, also have significant costs on the environment, both in its construction and use [22]. The natural environment and an assortment of stages of development in the global-, regional-, and city-scale are entangled in a complex manner [21]. Environmental influence is not always deliberate during the design, planning and construction of infrastructure projects to encourage the consideration of sustainability in these efforts. The main challenge that the Infrastructure and Environment research matter faces is to permit the development of eminent performing infrastructure while minimising its impact on the environment. Therefore, Environmental sustainability in concord with infrastructure development is the biggest challenge for the civil and environmental engineers [21].

## IV. NANOTECHNOLOGY IN INFRASTRUCTURE DEVELOPMENT: POTENTIAL AND FUTURE PROSPECTS

From above discussion it is clear that infrastructure facilities are the key for economical development of any nation and also its sustainability and environmental friendly characteristic are desirable for low maintenance cost, durability, strength enhancement, reduce construction cost, ease of construction, protection of environment with reduce adverse climate change effect on human being. Nanotechnology can play major and important role to achieve all this aspects of civil engineering field for infrastructure development. Let us see how nanotechnology is helpful and beneficial in civil engineering field for infrastructure development.

### (a) Nanotechnology and its application in cement based material:

One of the most widespread and advantageous uses of nanotechnology in terms of civil engineering, is the use of it in concrete. Concrete is the second highest commodity consumed after the water on the surface of the earth [23]. Concrete is used in almost all infrastructure development construction like – building, roads, dams, bridges, canal etc. Without the use of concrete one cannot image the construction sector and infrastructure development in the field of civil engineering [9]. Cement is the main ingredient of concrete which account for 10 to 15 percentage of concrete, one of the largest product utilised by mankind, is obviously the product with great potential but not completely explore [24]. In 2011, the usual total worldwide production of cement was 3,400 million tonnes and it is expected to increase the total worldwide production of cement to 6000 million tonnes up to 2050 [25]. Manufacturing of cement contributes greenhouse gases about 5% of global man-made CO<sub>2</sub> emissions [26-27]. The amount of CO<sub>2</sub> release by the cement industry is nearly 900kg of CO<sub>2</sub> for each 1000kg of cement manufactured.

Concrete can be tailored by bring in to play of nano material in concrete or producing nano cement. Advancements made by the explore of concrete at the nano scale is that particle packing in concrete can be modified by using Nano-material which direct to a densification of the micro and nanostructure [28] resulting in improved mechanical properties like durability, strength, stress-strain behaviour, easiness in placing etc [29]. By creating innovative technological tools and systematize the quantity and locations of nano materials in a controlled way, concrete can encounter the advances of nanotechnology. After all, concrete is a macro-structured material, sturdily prejudiced by its nano properties and understanding it at nano level can provide the path for enhancement of properties. The particle size of cement can be reduced to nano-size or can be specially made by addition of nano-tubes and reactive nano-size silica particles [30].

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Vol. 6, Issue 6, June 2017

## (b) Nanotechnology and its application in steel:

From the time when the second industrial revolution in the late part of the 19<sup>th</sup> and early part of the 20<sup>th</sup> Century steel has been widely available and has played a major role in the construction sector [31]. Weakness of steel is a critical issue that can direct to the structural failure of steel due to recurring loading conditions [7]. Failure can take place at extensively low stresses than the yield stress of the material and lead to a great extent reduction in service life. Stress attentiveness is responsible for early cracks which initiate flaw failure, and research has shown that the amassing of copper nano-particles reduces the surface unevenness of steel, which then limits the number of stress risers, and hence flaw cracking [3]. The addition of nano particles of magnesium and calcium leads to an increase in weld toughness. The carbon nanotubes have little application as an addition to steel because of their inherent slipperiness, due to the graphitic character, making them complex to bind to the bulk material. Also, the high temperature involved in the steel constituent production method enhances the vibration of carbon atoms significantly, leading to bond breaking and defects in the nanotubes structure [25].

## (c) Nanotechnologies for Wood :

Wood is composed of nanotubes or “nanofibres”. Ligno cellulosic surfaces at the nanoscale could unite novel prospect for such stuff as self purify surfaces, inners elf-repair and electronic lignocellulosic devices, offering response for product functioning and environmental conditions during service. Highly water resistant coatings integrating silica and alumina nano elements and hydrophobic polymers are appropriate to be used for wood [25].

## (d) Nanotechnologies for Glass :

Fire-resistant glass is another function of nanotechnology. This is accomplish by using a clear in tumescent layer sandwiched between glass panel produced of fumed silica ( $\text{SiO}_2$ ) nanoparticles which change into a rigid and opaque fire shield when heated [7]. The use of  $\text{TiO}_2$  nano material to glasses direct to so-called self cleaning technology. Due to the nano particles photocatalytic reactions, the unstable organic composite, organic pollutants, and bacterial membranes are decomposed. As well,  $\text{TiO}_2$  being hydrophilic, his enticement to water forms drops which then wash off the dirt particles decomposed in the previous process [25].

## (e) Nano Particles for fire protection :

Portland cement covering for fire safeguard of steel structures is applied in restricted as it is thick, liable to be brittle and polymer additions are required to enhance bond with steel surface. It has been observed that nanocement totting up by means of carbon nanotubes with the cement based material to fabricate fibre composites has outstanding properties of high strength and fire resistance [30]. Nano cement has capability to form a new concept in this field of application as the resulting material can be used as a durable, tough, high temperature coating. This can be accomplish by the addition of carbon nanotubes into cement based material to formulate fibre compound that can endorse outstanding properties of nanotubes as like strength [2]. Polypropylene fibres are also deem as a process of escalating fire resistance and this is a low cost option than traditional insulation [2].

## (f) Nanotechnology for water purification:

Nanotechnology can takes advantage of nano scopic material like carbon nanotubes and alumina fibers for water purification. In addition also make use of existence of nano scopic voids in zeolite filtration membranes and nano catalysts and magnetic nano particles. Nanosensors, like titanium oxide nano wires or palladium nano particles are used for exposure of contaminants in water samples, removal of sediments, chemical effluents, charged particles, bacteria and other pathogens. Nanotechnology can also be used to eliminate toxic component such as viscous liquid impurities, arsenic [2].

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Vol. 6, Issue 6, June 2017

## (g) Nanotechnology for coating:

Nanotechnology in coating is considered as one of the major application in civil construction sector [32]. In coatings, much of the work include Spray and Plasma, Chemical Vapour Deposition (CVD), Dip, Meniscus, Coating to create a layer which is be adjacent to the source material to prepare a surface of the desired protective or functional properties [2]. Nanotechnology is used in paints to guarantee the corrosion safeguard under insulation since it is hydrophobic and keeps away water from the metal pipe and can also safeguard metal from salt water attack [25]. Coating can have other applications such as –  $\text{TIO}_2$  nano particles are place to bring into play as a costing material on road construction to reduce nitrogen oxides concentration at street level self cleaning and self healing ability by process of “self assembly glazing”.

## V. CONCLUSION

Nanotechnology brings forward immeasurable quantity of improvement in the civil engineering field. It has help to improve the quality building materials and solved many issue related to it. Material developed using nanotechnology has made revolution in construction field with low cost technology and greatest positive impact on the society as well. Nanotechnology has the ability to be the key to a whole novel world in the field of construction and building materials. Nanomaterials and nanotechnologies have paying attention considerable scientific curiosity due to the new possible uses of particles at nano scale. Nanotechnology is a efficiently growing area of research where innovative properties of materials produced on nano-scale can be exploit for the benefit of construction infrastructure, and a number of promising developments exist that can likely revolutionize the service life and life-cycle cost of construction infrastructure to create a innovative globe in the future.

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