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A Review on Nanocomposite Material for Building Construction

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Abstract – The most frequent and beneficial uses of nanotechnology in terms of civil engineering, is the use of it in concrete. Furthermore, it has been observed that better understanding and engineering of complex structures made by cement, steel or composite materials at nano-level will definitely result in a new generation of construction materials with higher performance in strength, durability, and other properties The paper also includes applications and properties with which construction materials could be more affective, durable and high performing by using nano-materials. The smart designs and planning, construction projects can be made sustainable and avoid damage to environment. Nanotechnology offers opportunity to develop sustainable, light weight concrete structure for different adverse environments reducing energy consumption during cement production.

Keywords – Concrete, Construction, Nanocomposite, Nanomaterial, Nanotechnology.

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I. INTRODUCTION

Today nanotechnologies gives potential opportunities to create better material with enlarged properties for use in various application areas The construction industry it has possibilities that are already usable today, such possibilities can already see today through many current applications related for instance to surface coatings, self-cleaning capacities, and fire resistance ,and others.

Nanoscale assembler able to build a copy of itself and other items of arbitrary complex with atomic control. The manipulation of matter on an atomic, molecular and supramolecular scale is called as **Nanotechnology**.[1][15**] In simple words, using very small particles to create new large scale materials is called as nanotechnology**. Nanomaterials in concrete would be Nano- silica, Nano-clay and Nano-composites The particles are used either by themselves only or by manipulation.[7] Nanoparticles are materials at nanometric scale that range from 1 to 100 nm (Fahlman, 2011) and which can be nanopowders, nanowires, nanotubes, nanohorns, nanocrystals, nanopores, nanofilms, nanomembranes, nanofibers, etc.[1][4]. A Nanocomposite material is constituted by a matrix and a reinforcement consisting of fibers. The matrix itself comprises a resin and filler.[6] High degree of reinforcement is observed in the particle size range of 100 nm and below.[9] Nanotechnological exceptional characteristics of self-cleaning, self-repairing mechanisms in construction.[14][16].

The government has played a pioneering role in promoting nanotechnology R&D in India. It has taken many initiatives to foster and promote R&D in India through several of its departments. Many schemes/programmes have been launched for infrastructure and human resource development.[10]. The nanotechnology revolution experienced in the last few years had a huge impact on various science fields (chemistry, engineering, biology), also affecting the construction industry.[11]

On the bases of their engineering applications, nanocomposites can be classified either, Nanocomposites are mainly classified into two main categories are as follows :

1. **Polymer:** polymers/ceramic nanocomposite, inorganic or organic polymer nanocomposite, inorganic or o inorganic or organic hybrid nanocomposite, polymer /layered silicate, polymer nanocomposite, biocomposite.

2. **Non Polymer:** metal/ metal nanocomposite, metal/ceramic nanocomposite, ceramic/ceramic nanocomposite.[12]s

Ag, zinc oxide (ZnO), copper oxide (CuO), cerium dioxide (CeO2), titanium dioxide (TiO2), iron oxide (FeO), fullerenes, carbon nanotubes (CNTs), and a small number of others remain the most widely

used and researched nanomaterials (NMs), some newer NMs have been produced in recent years.[8]

Ceramic Matrix Nanocomposites (CMNC);

Metal Matrix Nanocomposites (MMNC) and

Polymer Matrix Nanocomposites (PMNC).[13]

Most popularly, nanocomposites are prepared by the process within in situ growth and polymerization of biopolymer and inorganic matrix. With the rapid estimated demand of these striking potentially advanced materials, make them very much useful in various industries ranging from small scale too large to very large manufacturing units.[5]

In architecture and construction industry, nanotechnology applications range from the improvement of the traditional mechanical properties of concrete, anti-corrosive protection for reinforcing steel, of materials and products such as paints, sealants and glass (to make them repellent to bacteria and other noxious biological agents) to the improvement of thermal and pyro-resistant properties of materials, to name a few.[2][12]. These include products that are for: coating, Improved pipe joining materials and techniques, Better properties of cementitious materials, Reduced thermal transfer rate of fire retardant and insulation, Increased sound absorption of acoustic absorber, Increased reflectivity of glass, water repellents, nano-clay filled polymers, self-disinfecting surfaces, UV light protector, air cleaners, nano-sized sensors, and solar cells.[3]

II. LITERATURE REVIEW

Said Jalali 2010

In [1] Nanotechnology is the key that allows construction and building materials to replicate the features of natural systems improved until perfection during millions of years. This paper reviews current knowledge about nanotechnology and nanomaterials used by the construction industry. It covers the nanoscale analysis of Portland cement hydration products, the use of nanoparticles to increase the strength and durability of cimentitious composites, the photocatalytic capacity of nanomaterials and also nanotoxicity risks.. Nanoscale analysis of Portland cement hydration products will allow more durable binders but the question related to when that will happen is not clear. The fact that nanoparticles are not cost-efficient prevents their commercial applications in a near future.

Silverio Hernández Moreno(2017)

In [2], on the basis of a review of scientific literature from the architect's standpoint. The applications divide and classify mainly according to the use of nanomaterials to improve their properties and functioning from a number of categories of construction materials such as: improvement of strengths of Portland-based concrete adding nanomaterials: improvement of reinforcing steel's corrosion and deterioration resistance adding nanomaterials. It is concluded that improvement to such materials by means of nanocomposites will depend on a number of situations such as: design, amounts, characterization and assessment of construction materials in relation to components and construction systems; weather and degradation conditions that affect materials; conditions of use and maintenance that affect the materials, procedures and quality in the production and construction of the components and materials.

Ali Akbar Firoozi (2014)

In [3],The potential for application of many of the developments in the nanotechnology field in the area of construction engineering has been growing. The objective of this study is to review the role of nanotechnology in civil engineering applications. It also discusses the application of instruments to reach material properties of nano-scale. Furthermore, it has been observed that better understanding and engineering of complex structures made by cement, steel or composite materials at nano-level will definitely result in a new generation of construction materials with higher performance in strength, durability, and other properties. Furthermore, nanotechnology is a rapidly expanding area of research where novel properties of materials manufactured on nano-scale can be utilized for the benefit of construction infrastructure, and a number of promising developments exist that can potentially change the service life and life-cycle cost of construction infrastructure to make a new world in the future.

Prof. Nuno Miguel Rosa Pereira Silvestre Prof. Jorge Manuel Caliço Lopes de Brito (March of 2015)

In [4], Nanotechnology is a revolutionary vector of technology development. It concerns the management of matter at the nanometer-scale (one billion times smaller than a meter). Its potentialities have changed the perspectives, expectations and abilities to manipulate the material world. Several technological areas have been largely affected, from chemistry to physics or electronics to mechanics. The construction industry has been given increasing attention to the investigation and use of nanomaterials, which justified this work. It is the expectation of the research community that a new generation of structures with enhanced mechanical and durability properties can be achieved with the use of nanomaterials. Considering all the aspects combined, some future routes and developments

with potential to be addressed by Portuguese scientific research institutions are finally proposed.

Mausumi sen,(2012)

In [5], Nanocomposites are the heterogeneous/hybrid materials that are produced by the mixtures of polymers with inorganic solids (clays to oxides) at the nanometric scale. Their structures are found to be more complicated than that of microcomposites. They are highly influenced by the structure, composition, interfacial interactions, and components of individual property. Most popularly, nanocomposites are prepared by the process within in situ growth and polymerization of biopolymer and inorganic matrix. With the rapid estimated demand of these striking potentially advanced materials, make them very much useful in various industries ranging from small scale to large to very large manufacturing units. With a great deal to mankind with environmental friendly, these offer advanced technologies in addition to the enhanced business opportunities to several industrial sectors like automobile, construction, electronics and electrical, food packaging, and technology transfer.

Shivani Pandya (2015)

In [6], nanocomposites can be based on a metal oxide matrix in which the filler is also metal oxide nanoparticles, nanowires, etc. The process can prepare highly metastable structures such as amorphous alloys and nanocomposite structures with high flexibility. Materials prepared by this method were used in a gas-sensing application. For example, it was found that sensors based on Fe2O3 (Sn, Ti, Zr) nanocomposites prepared this way showed improved sensitivity to ethanol and hydrocarbons.

N. Silvestre (2015)

In[7], the study of the application of nanotechnology in the construction industry and building structures is one of the most prominent priorities of the research community. It focuses on the most effective nano-additives that readily improve concrete properties. Besides summarizing the main nanomaterials used in concrete production as well as the results achieved with each addition, some future potential consequences of nanotechnology development and orienta-tions to explore in construction are discussed. The use of nanomaterials in the construction industry, further research results are needed in order to clarify some consequences about the use, production and design that are still not fully un-derstood. The main improvements re-sulting from these nano-modifications, also known as nano-engineering, include (i) better cement hydration, (ii) higher compressive or tensile strength, (iii) higher ductility and ener-gy dissipation, and (iv) enhanced ability to control cracking and shrinkage phenomena.

Amra Bratovcic(2019)

In[8],From this review, it is concluded that despite the advancement and development of new nanomaterials, they still have positive and negative effects both on the environment and on human beings. Since the shape, size and composition of nanoparticles can have both significant effects on their function and possible risks to human health, extensive research is needed to fully understand their synthesis, characterization, and possible toxicity.

Mrinal Bhattachary(2016)

In[9],In this article we review the processing of carbon nanotube, graphene, and clay montmorillonite platelet as potential nanofillers to form nanocomposites. The various functionalization techniques of modifying the nanofillers to enable interaction with polymers are summarized. The importance of filler dispersion in the polymeric matrix is highlighted. Finally, the challenges and future outlook for Nano filled polymeric composites are presented. The reinforcement of polymeric systems by nanoscale sized fillers has opened up the possibility of improving modulus and strength of composites using much lower filler content.

Amit Kumar (2014)

In[10], Nanotechnology has been heralded as a revolutionary technology by many scholars worldwide. Being an enabling technology, it has the potential to open up new vistas in the field of R&D in various multiple disciplines and have wide domain of sectoral applications, ranging from healthcare/medicines, electronics, textiles, agriculture, construction, water treatment, and food processing to cosmetics.

Nuno Miguel Rosa Pereira Silvestre (2015)

In [11], Nanotechnology is a revolutionary vector of technology development. It concerns the management of matter at the nanometer-scale (one billion times smaller than a meter). The construction industry has been given increasing attention to the investigation and use of nanomaterials, which justified this work. It is the expectation of the research community that a new generation of structures with enhanced mechanical and durability properties can be achieved with the use of nanomaterials. In that sense, the application of nanomaterials in the construction industry should be considered not only to improve the physical and mechanical material properties, but also for environmental protection and energy saving.

In[12], The objective of this paper is to presents the review and uses of nanotechnology in Civil Engineering. The paper also includes applications and properties with which construction materials

could be more affective, durable and high performing by using nano-materials. Complex Structures made by Cement, Concrete and Steel can be made at nano-level to improve their performance. Structures made at nano-level will definitely change the new era of construction as there are fast and durable results with lesser effort. Briefly, it can be understood that nanotechnology is very beneficial to many fields specially Civil Engineering. Vast amount of enhancement can be applied to many construction materials to improve their quality and solve many issues related to Civil Engineering.

Ujwal Prabhakar Nandekar, Rupal Rautdesai (2019)

In[13], Research has proven that with the help of nanotechnology we can improve the environmental quality of building. It is pertinent to note that various encouraging advancements prevail which can actually not only reduce the cost but also improve the service life and life cycle of construction infrastructure. Seeing huge benefit of incorporation of nanotechnology in all/ any kind of field, product, processes etc. for developmental purposes may bring challenges/ difficulties related to environment, health, safety risks, ethical and social issues, market adoptability and consumer approach.

Sajad Hussain Din1, M. A. Shah2, N. A. Sheikh1, M. Mursaleen Butt(2019)

In[14], Nanocomposites are high performance materials which reveal rare properties. Nanocomposites have an estimated annual growth rate of 25% and fastest demand to be in engineering plastics and elastomers. Therefore, nanocomposites are appropriate materials to meet the developing demands arising from scientific and technologic advances. Processing methods for different types of nanocomposites.

Bjorn BirgissonAnal K. Mukhopadhyay Georgene Geary Mohammad Khan Konstantin Sobolev(2019)

In[15], Nanotechnology is not simply working at ever-smaller dimensions; rather, working at the nanoscale enables scientists to utilize the unique physical, chemical, mechanical, and optical properties of materials that naturally occur at that scale. Of particular relevance for concrete is the greatly increased surface area of particles at the nanoscale. As the surface area per mass of a material increases, a greater amount of the material can come into contact with surrounding materials, thus affecting reactivity.

III. SUMMERY

Nanotechnology is one of the most active research area that include civil engineering &construction materials. They are highly influenced by the structure, composition, interfacial intereactions and component properties. . Nanoconcrete enhances various properties with different nanomaterials. It includes nanoscale analysis of different properties of cement like hydration, increase strength & durability of cementitious composites. Improvements of reinforcing steels corrosion &deterioration resistance adding nanomaterials. The high degree of reinforcement is observed in particle size ranges of 100nm &below. Nanocomposites, a high performance material exhibit unusual property combinations and unique design possibilities. It focuses on the most effective nanoadditives that readily improve concrete properties such as 1) Nanosillica &silica fumes 2) Nano titanium dioxide 3) Iron oxide 4) Chromium oxide 5) Nanoclay 6) $CaCO_3$ 7) Al_2O_3. 8) carbonnanotubes 9. Graphemeoxide the construction industry has been given increasing attention to the investigation &use of nanomaterials which justify work. It is expectation of research community that a new generation of structures with enhanced mechanical & durability properties can be achieved with use of nanomaterials. The possible consequences regarding its practicality and the most challenging economic factors concerned are discussed briefly. Finally its future trends &potential towards more economical, sustainable & eco-friendly infrastructure having longer durability are explained.

IV. TABLE

S. No.	TITLE OF PAPER	AUTHOR	METHOD	REMARK
1.	Nanotechnology: Advantages and drawbacks in the field of construction and building materials.	F. Pacheco-Torgal, Said Jalali	Laboratory methods	Increase of strength by 15-20%
2.	Applications of nanocomposites in architecture and construction.	Silverio Hernandez Moreno, Sara Cristina, Solace de la Torre	Laboratory methods	Enhance strengths of upto 23.3% more under compression and upto 13.6% more in flexion at 28 days.
3.	Nanotechnology in construction: Towards structural applications	Prof. Nuno miguel rosa pereira Silvestre, prof. Jorge manuel caliço lopes de brito	Scanning electron microscopy (SEM)	Increase of approximately 43.5% of the fracture toughness For an optimum value of 0.2 wt%
4.	Review on concrete nanotechnology.	N. Silvestre	Laboratory tests	Enhancement of concrete strength
5.	Different Applications of Nanomaterials and Their Impact on the Environment	Anzra bratovcic	-	Advancement and development of new nanomaterials
6.	Polymer Nanocomposites—A Comparison between Carbon Nanotubes, Graphene, and Clay as Nanofillers.	Mrinal bhattachary	SEM	Tensile strength increased by 42% and modulus by 90%
7.	Nanotechnology Development in India: An Overview	Amit kumar	-	Heat-resistant , self-cleaning surfaces
8.	Nanotechnology and Nanotech Materials in Civil Engineering	Arbaz rahmany, jamia polytechnic	Laboratory tests	Delayed fracture
9.	Nano-Composites and Their Applications	Sajad hussain din	SEM,TEM	12.6% increase in Hardness and 105.1% in Young's modulus
10.	Nanotechnology in Concrete Materials	Bjorn Birgisson Anal K. Mukhopadhyay Georgene Geary Mohammad Khan Konstantin Sobolev	Scanning transmission X-ray microscopy (STXM)	Durability increased

V. CONCLUSION

Closing gap between laboratory achievements and the real world suitability is the biggest challenge. Impact of nanotechnology on the commercial market has been influenced mainly by less awareness in industry. It needs excessive focus on locally available nanomaterials. The wide range of properties that makes nanomaterials so useful, like size, shape &surface characteristics. It

can also cause serious problems if material is not use properly. Hence with the proper precautions it can be reduce. The construction industry needs campaigns, marketing, promoting the use of nanomaterials with their benefits and their applications.

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