Nanotechnology in Civil Engineering Construction

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***Abstract*—The material behaviour of any construction depends mainly on structural elements, the later performance be subjected to the mechanical behaviour of its materials which are effective on a micro and nano-scale. The talent to target material improvement at the nano-structural level guarantees to convey the innovative of material conduct and performance expected to enhance essentially the mechanical performance, volume change properties, durability, and sustainability. The investigation of the utilization of nanotechnology in the construction development and building structures is a standout amongst the most unmistakable needs of the exploration network. This study presented an overall facts and explanations of nanotechnology and displayed a specific literature on the application of nanotechnology in the construction field, more particularly in concrete manufacture, steel, wood and glass. The utilization of nanotechnology in civil engineering is quiet in premature steps arrange. The generation techniques, contaminations caused to human wellbeing, fabricating troubles, execution are the issues to be tended to with the end goal to utilize the nanotechnology in construction field.**

***Index Terms*—nano-materials, nanotechnology, construction, civil engineering, nanoconcrete**

I. Introduction

The research precedence of nanotechnology schemes now is tremendous as nanoparticles have become part of our daily life. It is certain to emphasize that with the continued inundation and consideration of subsidies, there is nary a scientific space that has not gotten in the conversion process. Fundamental sciences like physics, chemistry, engineering, biology and computer are the greatest leading research , with some other fields adds more practical realizations to the development of nanotechnology . Indeed, even the sociologies and humanities have seen an influx of recommendations and calls for research, generally in the regions of morals and policy management.

Nanotechnology has important effect in the building sector. A few applications have been created for this particular sector to enhance the solidness and improve performance of building elements, energy efficiency and structures safety, encouraging the simplicity of support and to give expanded living solace.

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Beginning from the contemplations above, it ought not be amazing that nanotechnology much featured by the UNESCO Science Report: towards 2030 [1]. This was given to the worries and needs of nations that will situate the usage and drive the evaluation of the 2030 Agenda for Sustainable Development in the years to come. This report put the nanotechnology as one of the most critical fields in the patterns and advancements in science, innovation and development arrangement and administration for most nations.

Surveys from Sweden and the UK indicate that nanotechnology is the most promising invention in the construction industry, especially in concrete products [2]. Nanotechnology products can improve the construction materials used in civil engineering. The design and the construction process in civil engineering have benefited significantly from nanotechnology. The result of the technique in the field of construction is the production of light structures, durable structural composites, products that require low maintenance coating, increased reflectivity of glass, and better properties of cementitious materials [3]. The literature review will focus on some of the impacts of nanotechnology in civil engineering and especially in building materials such as concrete, steel, glass, and wood.

Nanotechnology is the manipulation of atoms and molecules by engineering matter at the atomic level [4]. It is the understanding and manipulation of data on a Nano scale [5]. Nanotechnology has attracted significant interest and has several applications that have influenced the field of civil engineering. According to Hossain and Rameeja (2015) [4], nanotechnology has opened new ways of constructing materials required in the field of civil engineering. Nanotechnology has led to the creation of fire-resistant materials such as steel, long-lasting concrete, and other helpful materials.

The fundamental goal is to give the pursuer the chance of the understanding what has been done in the nanotechnology towards construction industry what still stays to be tended to, and additionally which are empowering elements of this transformative procedure and what are its shortcoming and risk factors.

The reminder organization of the paper as pursues. In section 2, we present the impact of nanotechnology on concrete preparations as the most utilized materials in construction industry. The nanotechnology and steel are the subject of section 3, while the utilizations of this

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innovation in the field of wood and glass was tended to in sections 4 and 5 separately. Conclusions and future ability are given in section 6.

II. Effect of Nanotchnology Application on Concrete

Concrete is one of the most used building materials in civil engineering. Nanotechnology has influenced the manufacture of concrete in a myriad of ways. The excellent properties of nanotechnology have led to the enhancement of physical and chemical properties of cement, interfacial, and surface effects [6]. The product of mixing nanomaterial with concrete to increase stability is referred to as nanoconcrete. Self-Compacting Concrete (SCC), which is a type of nanoconcrete, increases the stability of Portland cement by increasing concrete durability and aesthetic appearance. The presence of this component in concrete reduces the amount of material needed in buildings [7]. Furthermore, Nano-Silica, which is another type of nanoconcrete, improves the nanostructure and mechanical properties of concrete. Besides, Nano-Silica has lower water consumption and reduces the amount of concrete required in the construction site. Equally important, a study by Wang et al. (2016) [6] found that Nano-Silica when mixed with concrete, reduced the porosity of concrete, promoted the hydration heat of cement paste, and increased the compressive strength of Portland cement. Mohamed (2014) [8] found that the adding of Nano-Silica in wet conditions increased the compressive strength more than regular concrete that lacks Nano-Silica. Besides, the flexure strength of the cement also increased during wet conditions. Another study by Saloma et al. (2015) [9], found that the concrete compressive strength of Nano-Silica increased as days go by, Nano-Silica improved the performance of cement, and it increased the resistance of cement from sulfate attack. Nano-Titanium Dioxide TiO_2 allowed the concrete to maintain its aesthetic attributes for a longer time. The component is also essential since it gives the surface a self-cleaning effect [7]. A study by Glenn (2013) [10] utilizing the homogenization model found that the increase of Nano-Silica in a sample of cement increased strength and stiffness. Computational results of the study also indicated similar findings regarding the influence of Nano-Silica on the strength and rigidity of concrete. The study also found that nanomaterial elements in the air-entrained type of cement caused a denser cement matrix, decreased permeability, and increased concrete strength [10].

III. Effect of Nanotchnology Applications on Steel

Steel is an essential material in the field of construction. It has been in existence since the second industrial revolution [11]. Corrosion and lack of strength are some of the challenges that make steel unfavorable for construction; however, nanotechnology has had significant influences on the material. Nanotechnology can influence the power of steel products and lower the material usage [12]. Nanoparticles also enhance the corrosion-resistance of steel making it durable. Equally important, stress riser is one of the limiting factors of steel. The corrosion-resistance ability of nanotechnology protects various products such as oil steel pipes from corrosion. Research by Saurav (2015) [11] indicates that copper nanoparticles can reduce the surface unevenness of steel, which lowers the numbers of stress risers. This technology leads to increased safety and efficient materials for construction that require minimal monitoring. Moreover, the addition of calcium and magnesium nanoparticles makes the welds, and the heat affected zones (HAZ) grains finer in plate steel.

A study by Wansah et al. (2014) [13] indicated that nanotechnology had influenced the development of smart corrosion-inhibiting pigment in the form of a powder, which is used as an anti-corrosion coating. The particles in the corrosion-inhibiting pigment act as Nano scale reservoirs for the corrosion inhibitor. The traditional types of insulation used before on steel oil pipes encouraged moisture to be trapped inside; hence, creating a perfect ground for corrosion. Nanotechnology helps insulate and reduce the instance of corrosion on the steel oil pipes. Besides, nanotechnology plays a crucial role in the metallurgy of steel. Russian metallurgists have used nanotechnology in the reduction of Ural steel.

The process involves micro alloying steel with nitride phases in combination with plastic-deformation nanotechnologies that assist in strengthening the steel [14]. The steel also becomes cold and corrosion resistant. Fatigue is a common problem evident in steel structures such as bridges, which collapsed due to the repeated loading and unloading. The presence of nanoparticles of copper enables steel to maintain its structural integrity even at high temperatures such as 540 degrees Celsius [12].

IV. Effect on Nanotchnology on Wood

Wood is an essential material in the field of construction. Wood has been in existent for many years despite its drawbacks such as fire, decay, dimensional instability, and degradation because of weathering [15]. Different means to extend the durability of wood have been applied for many years, but have proven futile. Nanotechnology proves to have a significant impact on protecting timber and increasing longevity. Nano-based treatments using nanoxides such as TiO_2, ZnO, SiO_2, and CeO_2 minimize reaction to fire and hygroscopic properties, block ultraviolet radiation, and improve scratch and abrasion resistance [15]. Oke, Aigbavboa and Semenya (2017) [16] argue that nanotechnology will bring about a durable type of wood that will have hyper-performance when used in severe environmental conditions. Additional nanotechnology techniques are under research, and once they become applicable, they will have a significant impact on the quality of wood for construction. For instance, researchers are trying to exploit the Nano scale properties of wood to produce a new material that would be light, bio based, and multifunctional to compete with steel and concrete [17].

Researchers believe that the extraction of Nano fibrils will make wood cheaper than manufacturing carbon nanotubes. Although critics argue that the technological advancements might affect the environment, it is evident that thorough research will yield results that will transform the field of construction.

V. Effect of Nanotchnology Application on Glass

Glass is another material that is used in the construction industry. Glass is frequently positioned in the exterior surface of buildings for the penetration of light. Glass is also susceptible to corrosion and decay. The combination of water and atmospheric gases causes weathering, which is detrimental to the sustainability of the glass [18]. Nanotechnology can influence the structure of glass materials and increase longevity as well as the reduction in corrosion.

Nanotechnological solutions such as thin coatings are being developed for window glass. The coat has a significant impact of filtering out unwanted infrared frequencies of light; hence, reducing the heat in buildings [19]. Additionally, thermo chromic technologies are under study and can provide thermal insulation, minimize heat in the room, and provide the required lighting. The presence of Titanium dioxide (TiO_2) nanoparticle in glass has a significant impact on the sustainability of glass. The particles can break down pollutants, volatile organic compounds, and are attracted to water, which assists in washing off the contaminants from the glass. Furthermore, the coating of glass with silica (SiO_2) nanoparticles makes the glass rigid and opaque to fire [20]. Jones et al. (2015) [21] also found that Nano-silica intumescent layers influence the properties of the glass by making it a high-grade fire safety for thirty years.

Altavila (2006) [18] found that nano-coatings with alkylsilanes (OTS) and fluoroalkylsilanes (FAS) significantly modify the glass wetting properties without changing the visible appearance of the glass. The technology played a crucial role in protecting the glass from water and atmospheric gases that cause weathering and decay. In this case, it can be said that nanotechnology significantly influences the sustainability of glass products making them suitable for construction purposes.

VI. Conclusion

Nanotechnology has gained popularity in various industries including the construction industry. The field of civil engineering has benefited significantly from nanotechnology. Nanotechnology techniques have illustrated positive outcomes regarding its use in concrete, glass, wood, and steal. Nanotechnology has helped in the production of long-lasting, durable, and efficient construction materials.

In perspective of the information inspected in this review, the going with conclusions are drawn that nanotechnology is a quickly increasing district of research where novel properties of materials created on the Nano scale can be used in civil engineering fields . Regardless of the truth that the cost of nanotechnology-engaged materials and contraptions may keep their over the board application construction industry at the present stage, their cost is depended upon to drop as soon as possible. What's extra, the focal points from nanotechnology's application could legitimize the additional cost. Regardless, the supportive changes that nanotechnology may pass on to construction industry could be limited if designers require appropriate vision and thoughtfulness regarding potential nanotechnology applications for construction industry.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

Ahmed A. Ajel conducted the research and wrote the entire paper; the author had approved the final version.

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