The Effect of Nano Materials on Self-Compacting Concrete – A Review

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Abstract. One of the potential ideas that has lately attracted attention is the use of nanoparticles in concrete. Various programmes have evolved over time to enhance the durability of concrete. Although most uses of nanomaterials to improve concrete qualities are restricted to laboratory experiments, additional commercial applications are envisaged in the future years. Many types of nanoparticles that are already employed in concrete and their impact on durability were investigated in this study. Nano-silica was discovered to be the most widely employed nanomaterial in concrete. Furthermore, nanoparticles in all existing forms greatly increase concrete durability when compared to other approaches employed prior to the introduction of nanomaterials in concrete. Other nanomaterials, such as nano titanium oxide and nano aluminum oxide, are becoming more popular. However, the use of nanoparticles in concrete has various drawbacks, including high cost, production method, and toxicity. Further study and application of nanoparticles to improve concrete qualities is predicted to result in the creation of low-cost and simple-to-use nanomaterials. Furthermore, the usage of nanoparticles has the potential to increase present durability attributes.

Keywords: Carbon Nanotube, Nano silica, Nano titanium oxide, Nano Alumina, Durability, Self-Compacted Concrete

INTRODUCTION

Concrete is the basic material on which our physical infrastructure is built. Concrete is used as a construction material in a variety of applications, including the construction of roads, buildings, bridges and dams. The high resistance of concrete to many adverse environmental influences, as well as its enormous strength, make it the preferred and most widely used building material in the world. However, since concrete is a somewhat porous material, it is still subject to many harmful environmental issues. Therefore, it is of great importance to ensure that the concrete is durable and strong to ensure a longer service life of concrete structures. The quality of concrete that shows the ability to withstand these environmental degradation factors is called "durability" and is highly dependent on the components used to make the concrete. Despite the development of various types of high-strength concrete, durability remains a central issue for all types of concrete. Over time, various methods have emerged to improve the durability of concrete in different environments. Most methods to improve the durability of concrete involve the use of chemical and/or mineral admixtures. For example, an air drying agent is a chemical additive used in concrete to improve its resistance to freezing and thawing. In addition, mineral admixtures such as slag and fly ash can improve the durability of concrete through the action of pozzolanics and filler, thereby intensifying the microstructure of concrete.

Additionally, the use of nanomaterials can be employed to minimize the amount of OPC required, as this in combination with a lower amount of OPC can result in comparable strength. Nanomaterials are materials with sizes in the nanometer to submicron range. Nanoparticles (0D), nanotubes (1D and 2D) and nanosilica [4] are some of the most common forms of nanomaterials used in concrete.

In latest years, maximum efforts to boom concrete sturdiness have targeted at the macrostructure and microstructure of concrete. Understanding and improving the characteristics of concrete are actually the order of the day, as substances technology and generation evolve. To the fine of the author's knowledge, the bulk of critiques at the software of nanomaterials in concrete are targeted on electricity enhancement. As a result, this evaluation focuses most effective at the influences of nanomaterials at the sturdiness of concrete. It is predicted that this newsletter could spur greater studies into using nanomaterials in concrete. And will act as a reference factor for different scientists running on specific approaches to enhance the sturdiness of concrete.

LITERATURE REVIEW

The Impact of Nanomaterials on Concrete Durability

The benefits of nanoparticles on concrete durability are further investigated depending on the most prevalent types of nanomaterials employed.

1.1.1 Nano silica.

This is the foremost common sort of nanomaterial utilized in concrete. this can be as a result of its without delay available, incorporates a characteristic pozzolanic reaction, and has a wide surface area, all of that accelerate the first age of concrete once mixed into a building material mix. They are available in sol or dry gain kinds [4]. Nonetheless, the colloidal suspension form is most popular for usage in concrete since it's going to be enclosed while not extra processing. Camillo et al.[5] shown that colloidal suspension types outperformed dry grain types in terms of characteristics. Owing to its pozzolanic reaction and acceleration of the association reaction, nano silicon dioxide is employed to extend the sturdiness of concrete [6]. The pozzolanic reaction promotes the synthesis of calcium silicate hydrate, and the acceleration of the hydration reaction promotes the formation of additional hydration products, resulting in densification of the microstructure [4]. Due to its size, nanosilica can also act as a pore filler in addition to these abilities. It has been shown that the addition of nanosilica to concrete significantly reduces water absorption compared to the control without nanosilica [7, 8]. The results of mercury-intrusion porosimetry (MIP) show reduced values for concrete with nanosilica up to a dose of 6% [4]. According to Du et al. [9] the addition of nanosilica makes the microstructure more homogeneous and less permeable. This finding was shared by Ji [10] who concluded that the addition of nanosilica to concrete caused interfacial transition zone (ITZ) compression. These benefits have been attributed to the reactive and filling effect of the nano pozzolanic silica. Ji [10] showed that using 3.8% nanosilica in concrete could reduce the water penetration depth by about 45%. Piper et al.[11] also showed that the use of 6% nanosilica significantly reduced the rate of calcium leaching from the cement paste. Concrete with 1% nanosilica was found to have higher chloride resistance compared to the control [12]. In addition, Quercia et al. [13] reported an overall improvement in self-compacting concrete with the incorporation of nanosilica into the mixture, despite the negative effects of nanosilica on fresh properties of concrete. Concrete containing timber significantly reduced chloride permeability and water absorption [14].

1.1.2 Nano-titania.

Zhang and Li [15] showed that the pore structure of concrete can be refined with nano titanium dioxide. Adding nano-titanium dioxide to concrete reduced the permeability and improved the durability of the concrete. Furthermore, nano-titanium dioxide has been shown to accelerate the reactivity of tricalcium silicate, one of the main phases of clinker [16]. As the reaction rate increases, more reaction products are formed, further compacting the concrete microstructure. This is consistent with the results of Zhang and Li [15], who found that incorporating nano-titanium oxide into concrete resulted in a finer pore structure than incorporating nano-silica at the same dosage. Mohseni et al. [17] also showed that when nano-TiO2 was combined with rice husk ash to improve the durability of concrete, the water absorption rate was significantly reduced.

1.1.3 Nano alumina.

These nanoparticles are derived from alumina and have received less attention in concrete than other types of nanomaterials. Nano-alumina improves the durability of concrete by acting as a nano-filler and densifying the nanostructure of concrete [18]. This compaction makes the concrete less permeable and reduces the penetration of harmful ions into the concrete. Farzadonia et al. [19] found that incorporating nano-alumina into concrete improved durability and reduced gas permeability. Their study found that the addition of 1 wt.% nano-alumina to the binder can significantly reduce the permeability of concrete.

1.1.4 Carbon nanotubes.

Carbon nanotubes (CNTs) are characterized by tubular hollow channels made of graphene layers [20]. Their attractive properties have led to extensive research and use in various industries, including the concrete industry [21]. Their properties include size range (from 1nm to 10nm) and increased strength. “CNT is one of the toughest and most robust materials found in nature,” Dai wrote[21]. CNTs have been reported to fill the gaps at the nano-hi level and improve the durability of cementitious composites such as concrete [22, 23].

1.1.5 Graphene nano platelet.

The 2-D form of graphene nanoplatelet (GNP) lets in it to minimise the permeability of cement composites including concrete [9, 24]. When as compared to the control, GNP at a dose of 1.5% decreased permeability through as much as 37% in concrete [9]. This kind of nanomaterial's decreased permeability prevents the go with the drift of water, chloride, and different dangerous ions into the concrete. When GNP is hired at a dose of 2.5% through mass of the binder, the intensity of water penetration in concrete may be decreased through as much as 64% [25]. Peyvandi et al [26] determined that a smaller dosage of GNP would possibly lessen concrete permeability even as boosting acid resistance.

1.1.6 Polycarboxylates.

These nanomaterials have been used to alter the hydration of the main binder of concrete and improve its workability [28]. Additionally, the use of Polycarboxylates as water reducers at low water-to-cement ratios resulted in durable self-consolidating concrete (SCC) with fewer voids. It has also been found that Polycarboxylates change the microstructure of concrete, resulting in a less permeable concrete [29]. Concrete constructed with Polycarboxylates is more durable than concrete made with silica fume [30].

1.1.7 Nano kaolin and nano metakaolin.

These nanomaterials, as the name suggests, are made by processing kaolin. However, just as kaolin can be calcined to increase its reactivity, nano kaolin can be calcined to produce nano metakaolin, which has higher reactivity. Although the use of nano-metakaolin to enhance the durability of concrete is limited, its application in concrete is expected to result in greater improvement than known metakaolin.

1.1.8 Nano iron oxide.

Another form of metallic nanomaterial that can be used to increase the durability of concrete. As with other forms of nanomaterials, its ability to polish and densify the microstructure of the cementitious matrix enhances its durability. According to Figure 1, the concrete with iron nano oxide had lower chloride penetration and water absorption than the control. According to the available literature, this form of nanomaterial has been less studied and future research on this material could provide additional information on how it can be used to improve the durability of concrete.

1.1.9 Nano zirconia.

The incorporation of nano zirconia into concrete as shown in Figure 1 has been shown to increase the durability of self-consolidating concrete in terms of chloride penetration and water absorption. In fact, this form of nanomaterial has a higher resistance compared to nanomaterials such as nano titanium oxide and iron nano oxide.

1.1.10 Nano copper oxide.

Copper anoxide is made from copper oxide, which is a by-product of the metallurgical industry. Few researches have examined the use of this nanomaterial to improve the properties of concrete. When copper nano oxide is applied in concrete at a dosage of 3%, the water permeability is reduced [31]. This decrease in water permeability was attributed to early hydration and an increase in the amount of hydration products generated. Mehrinejad et al. [32] also found that the use of copper nano oxide alone or together with fly ash significantly reduced the chloride permeability of concrete. Madamdoust et al. [33] also observed a 44% increase in chloride permeability.

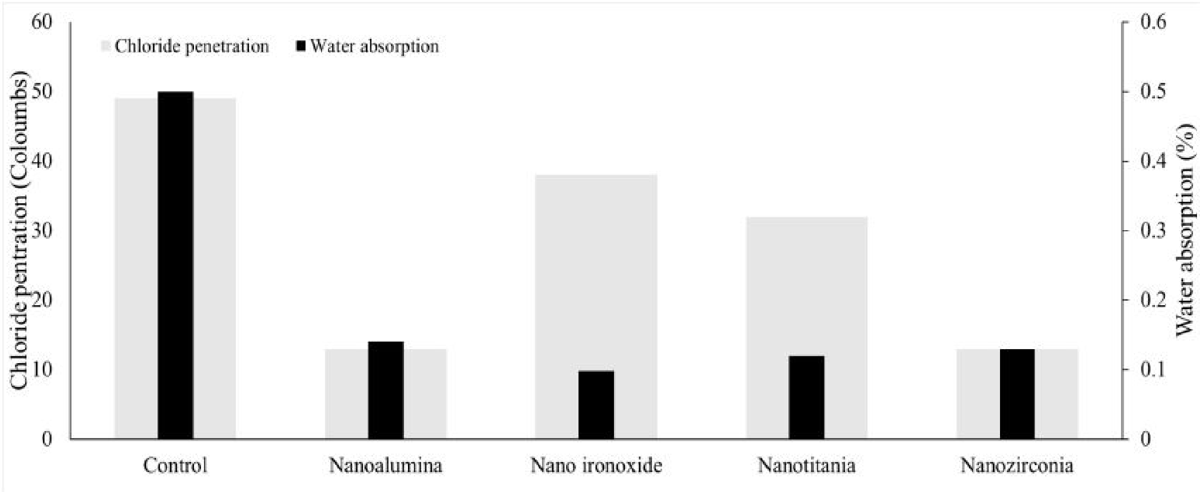

Figure 1: **CHLORIDE PENETRATION AND WATER ABSORPTION OF CONCRETE INCORPORATING DIFFERENT TYPES OF NANO PARTICLES (REDRAWN FROM [27])**

MAIN CHALLENGES

Although nanoparticles have some promising advantages, their use in concrete is currently hampered by significant limitations. Some of these limitations are briefly explained below.

1) Air Pollution:

Due to their small size, these compounds pose an environmental hazard as they are easily airborne and inhaled by living beings. Yu et al. [34] identified symptoms associated with exposure to nanomaterials such as nano titanium oxide. Therefore, extreme caution is required when handling these materials.

2) Expensive instrumentation:

The production of nanomaterials requires a variety of expensive and scarce equipment and methods, making nanomaterials expensive. Hammel and colleagues (2004) This is due to the limited use of current nanomaterials. Using nanoparticles to improve the quality of concrete comes at a cost, so scientists turned to alternative materials with fewer benefits. However, as nanoparticle applications develop in many fields, it is hoped that inexpensive methods will be found to produce these nanomaterials on a large scale.

3) Limited knowledge:

Some of these nanomaterials, such as CNTs and nano-alumina, have received little attention from the concrete industry in terms of improving concrete quality.

4) Impact on fresh properties:

Incorporation of nanoparticles into cement/concrete has been shown to reduce concrete curing time and workability [35, 36]. This problem has limited the use of nanoparticles in specialty concretes such as self-compacting concrete [37].

5) Cluster formation of nanoparticles:

The use of some types of nanoparticles in bulk binders can result in agglomeration or agglomeration, rendering them ineffective. For example, Du et al. [9] he suggested his 1.5% dose of CLT to increase concrete durability. His GNP after the suggested substitution level is shown to be ineffective due to clustering.

6) Standard:

There is no standard that can be met when using these nanoparticles compared to other elements put into concrete to improve durability. The majority of modern concrete construction is done in the laboratory and dosages are chosen based on literature and personal preference.

CONCLUSION

The use of nanoparticles in concrete is an upcoming trend that is set to expand rapidly due to their ability to enhance both strength and durability. As the production of OPC is one of the main contributors to greenhouse gases in the environment, the use of nanomaterials in concrete will provide a long-term benefit by reducing the amount of ordinary Portland cement (OPC) used in concrete. This review has shown that different types of nanomaterials can be used in concrete to increase durability while increasing strength. Further research and development into the use of nanoparticles in concrete will lead to wider applications and the introduction of standards to guide their users.

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