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Nano Technology in Concrete- A Brief Review

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Abstract - *Concrete is the most consumed material in construction field. Therefore, continuous research is conducted to enhance the properties of concrete. Nanotechnology refers to the study of structures between 1 Nanometer (nm) and 100 Nanometers in size. It is also broadly used in various fields of biomedical, robotics, electronics. Incorporating Nanotechnology in concrete to enhance its properties is one of the most dynamic research areas today. This paper discuss and reviews the studies performed so far on Nanotechnology in concrete by the use of Nano materials like Nano silica, Nano TiO_2, Nano Al_2O_3, Nano Fe_2O_3, Nano $Zr0_2$ in concrete as a partial replacement of cement. The impact of Nano materials on the properties of concrete is studied. Various Nano materials that are used in concrete are briefly explained and the comparison of their effect on concrete is discussed in this paper. This review work will help in better understanding of application of Nanotechnology in concrete.*

Key Words: *Nanotechnology, Nano materials, Nano particles, concrete*

1. INTRODUCTION

Nanotechnology is characterized as the study and utilization of any structures between 1 Nanometer (nm) and 100 Nanometers in size. Nanotechnology enables to control and modify the material properties at Nanoscale. The improvement in Nanotechnology has helped to implement Nano materials to be used in concrete. The utilization of Nano materials in concrete contributes to enhance the performance of concrete. Various researches are performed worldwide on the implementation of Nanotechnology in concrete. Nano materials are successful in modifying the concrete quality. The Nano materials used in concrete are Nano silica, Nano titanium dioxide, Nano clay, Nano aluminium dioxide, carbon Nanotubes, Nano ferrous oxide, Nano zirconium dioxide. Some of the Nano materials are briefly explained in the following sub section.

1.1 Nano-silica

Silicon dioxide Nanoparticles or Nano silica is the first Nano product that replaced the micro silica. Enhancement made by the study of concrete at Nano scale has evidenced Nano silica to be vastly improved than silica used in conventional concrete. Using tools of physics, chemistry and recent Nano technology, Nano silica was developed and it had superior advantages in comparison with micro silica. Its properties permit high compressive strength, durability and impermeability, and they have been part of numerous vital concrete structure. Addition of Nano-silica to cement based materials can control the degradation of the fundamental C-S-H (calcium-silicate-hydrate) gel of concrete brought by calcium leaching in water as well as block water penetration and therefore lead to improvements in durability.

1.2 Nano Titanium Dioxide

Nano titanium dioxide is available in two crystal forms of rutile and anatase. It has high purity, good transparency and tremendous UV absorption. It additionally has high thermal and chemical stability. With its smaller particle size and high specific surface area, the rutile form gives a fine and smooth feel suitable for sunscreens and cosmetics. It is widely used in the generation of beauty care products, sunscreen, and high-review plastics. The use of Nano titanium dioxide in concrete develops the strength and overall mechanical qualities of concrete.

1.3 Nano Iron Oxide

Iron oxide nanoparticles have attracted extensive interest due to their super paramagnetic properties and their potential applications in many fields. There are two main forms of iron oxide nanoparticles. They are Fe_20_3 and Fe_3O_4. They have many applications in construction industry, but of particular interest are as an anti-corrosion agent in construction materials and coatings. Iron oxide nanoparticles have very good UV blocking abilities.

2. REVIEW OF LITERATURE

Deepika Rana et al (2018)[1] studied the mechanical properties – compressive strength and workability of M20 and M30 grade concrete with partial replacement of cement with Nano Silica (0.5%, 1.0%, 1.5%, 2.0%, 2.5%) and compared with conventional concrete. Slump cone test was conducted to test the workability of concrete. It was seen that the concrete with 0.5% Nano silica yielded maximum workability whereas the concrete with 2.5% Nano Silica showed minimum workability. The workability of conventional concrete as more compared to that of the concrete with Nano Silica. The 7 day and 28 day compressive strength of concrete corresponding to 0.5%

Nano silica was reduced as compared to the conventional concrete. The values of strength started increasing for concrete with 1%, 1.5% and 2% Nano silica and further decreased for concrete with 2.5% Nano silica. It was concluded that workability of concrete decreases by increasing the amount of Nano silica and 2% silica dosage was concluded to be the ideal dosage for partial replacement of cement in concrete.

Jay Sorathiya et al (2017)[2] The workability and strength parameters of M20 grade of concrete were analysed with the use of Anatase form of Nano Titanium Dioxide (TiO_2). The various proportions of TiO_2 used in concrete were 0.5%, 0.75%, 1.0%, 1.25%, and 1.5% by weight of cement. The workability of concrete was analysed using slump cone test. The use of Nano Titanium Dioxide in concrete reduced the workability with increase in proportion of Nano TiO_2, workability of concrete with 0.5% was maximum and that of concrete with 1.5% was minimum. The results of 7 days and 28 days compressive strength showed gradual increase in strength with increase in proportion of Nano TiO_2 from 0.5% up to 1%, and gradually decreased with higher proportion of Nano TiO_2. It was concluded that the ideal level of Nano TiO_2 particle content is 1%.

P. Vasanthi et al (2017) [3] The durability of M40 grade concrete cubes with 2% of Nano silica were analysed by immersing the cubes in HCL (acid test), NaOH (alkaline test) and Na_2SO_4 (sulphate test). The chemical solutions for curing were prepared by mixing the respective chemicals with water. The concrete cubes were immersed in chemical solution containing 0.5ml of HCL with 6 litres of water for acid test, 24gms of NaOH with 6 litres of water for alkaline test and 426gms of Na_2SO_4 in 6 litres of water for sulphate test. The cubes were immersed in the respective chemical solutions until the day of testing. For the concrete cubes subjected to acid test, the 14 days, 21 days and 28 days compressive strength of concrete cubes with 2% Nano silica showed 15% increase in strength with respect to nominal concrete. For the concrete cubes subjected to alkaline test and sulphate test, the 14 days, 21 days and 28 days compressive strength of concrete cubes with 2% Nano silica showed 20% increase in strength with respect to nominal concrete. It was concluded that addition of Nano silica to concrete results in an increase in the compressive strength and durability when compared to the ordinary concrete.

Saloma et al (2015)[4] The compressive strength and resistance of Nano material concrete was investigated to sulphate attack by partial replacement of cement with Nano silica and constrained with concrete without Nanomaterial. Size of Nano silica used was 10- 40 nm with a mixed composition of 10% of cement weight. Cylindrical specimens were tested for compressive strength at the age of 3, 7, 14, 21 & 28 days. It was observed that the strength of concrete containing Nano silica was higher than the concrete without Nano silica. To examine the resistance of concrete to sulphate attack, the specimens were cured for 28, 56, 90, 120, 150 & 180 days in 50 gms/l solution of sodium sulphate and then the proportion of loss of weight and loss of strength to compressive strength of samples were determined. The loss in weight and loss in strength of concrete with Nano silica was very less when compared to concrete without Nano silica. It was also concluded that Nano silica has capability of enhancing the performance of concrete in terms of durability.

A. H. Shekari and M.S. Razzaghi (2011) [5] the impact of Nano materials on mechanical properties were studied through the compressive and indirect tensile strength and durability parameters of concrete were studied through chloride penetration test and water absorption. The unvarying content of Nano-ZrO_2 (NZ), Nano-Fe_3O_4 (NF), Nano TiO_2 (NT) and Nano- Al_2O_3 (NA) in each specimen was 1.5% of weight of cementitious material. The mechanical properties of concrete with Nano-particles were compared with concrete without Nano-particles. Compressive strength test were conducted on three cubic samples for each mixture. Indirect tensile tests, chloride penetration test, water absorption tests were performed on three cylindrical samples for each mixture. The results presented for the tests were the average of three samples of each mixture. The compressive strength and indirect tensile strength of concrete specimens with Nano particles was higher in each case compared to control specimen. It was seen that influence of NA and NF was maximum to improve the compressive strength and indirect tensile strength respectively as compared to other Nano particles. Nano particles reduced the water absorption and chloride penetration of concrete specimens. The values of the water absorption (in %) in all of the concrete samples with Nano-particles were less than 0.4 of water absorption of control specimens. The reduction of chloride penetration in various specimens is 20% to 80%. All the examined Nano-particles showed improved durability and mechanical properties of the concrete when compared to concrete without Nano-particles. The influence of Nano-Al_2O_3 on enhancement of mechanical properties of high performance concrete was most effective than the other Nano-particles when tested for compressive strength, indirect tensile strength, water absorption and chloride penetration.

Ali Nazari et al (2010) [6] The influence of Al_2O_3 on workability and compressive strength of binary blended concrete was investigated. The particle size of Nano Al_2O_3 used was 15 nm. Two series of concrete mixes were prepared, one as control specimens (without Nano particles) and other with Nano Al_2O_3 as cement replacement of 0.5%, 1.0%, 1.5% and 2.0% by weight. The workability of fresh concrete was determined. It was observed that the concrete mixture with Nano Al_2O_3 has low slump and it decreases with increase in Nano Al_2O_3 content. It was explained that the substitution of cement with a fine powder raises the water demand due to

increase in surface area. The concrete cubes were casted, cured and tested for compressive strength at the age of 7, 28 & 90 days. It was seen that the compressive strength increases with Nano Al_2O_3 particles up to 1.0% replacement and then decreases. But the result at 2.0% replacement was still greater than the result of control specimen. It was concluded that the concrete with Nano Al_2O_3 particles had significantly higher compressive strength as compared to that of concrete without Nano Al_2O_3 particles and cement could be beneficially replaced with Nano Al_2O_3 up to maximum limit of 2.0% with average particle size of 15nm. However, the optimal level of Nano Al_2O_3 particles content was attained with 1.0% replacement. Partial replacement of cement by Nano Al_2O_3 particles decrease workability of fresh concrete, therefore use of super plasticizer is required.

Ali Nazari et al (2010) [7] The effect of Nano TiO_2 particles on the cement paste composites is studied. Nano TiO_2 with average particle size of 15nm was used. Two series of concrete mixes were prepared. One series as control specimens and other with different quantities of Nano TiO_2 particles with cement replacement of 0.5%, 1.0%, 1.5% and 2.0% by weight. The workability of fresh concrete were analysed using the slump test. The workability of concrete with Nano TiO_2 particles was very low and non-acceptable. It was seen that the concrete with higher quantity of Nano TiO_2 particles showed lesser workability. The concrete cubes were casted and cured until the day of their testing for compressive strength at the age of 7 days, 28 days and 90days. The results showed that the compressive strength increases with Nano TiO_2 particles up to 1.0% replacement and then it decreases. However, the compressive strength of 2.0% replacement concrete was still greater than the plain cement concrete. It was concluded that cement could be beneficially replaced with Nano TiO_2 particles up to maximum limit of 2.0% with average particle size of 15nm. However, the optimal level of Nano TiO_2 particles content was attained with 1.0% replacement. It was also reported that the use of super plasticizer was mandatory since the partial replacement of cement by Nano TiO_2 particles decreased the workability of fresh concrete.

3. DISCUSSION

The comparison of the results of compressive strength from few of the studies discussed above is graphically shown below.

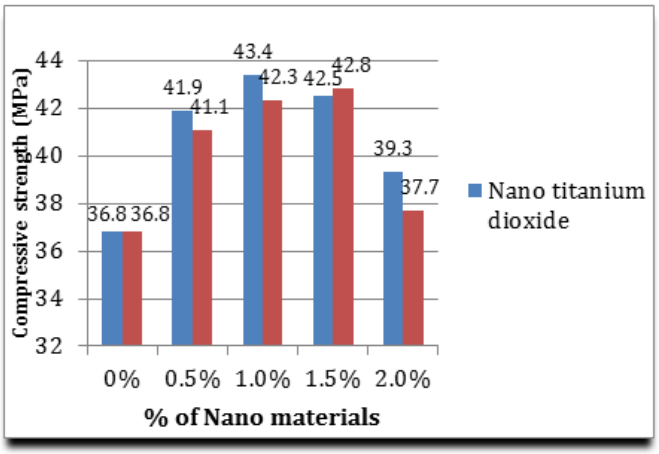

Chart -1: Comparison of compressive strength of M25 concrete with different proportions of Nano ti

4. CONCLUSION

After studying and presenting the most relevant and recent research work conducted on the application of Nanotechnology in concrete, it is concluded that Nano materials successfully enhance the properties of concrete. The strength, durability, resistance to sulphate attack and impermeability of concrete is higher improved by use of nanomaterial. Although, the mechanical properties of concrete are enhanced but the workability of concrete decreases therefore use of super plasticizers is substantial. The research so far is conducted on and below M40 grade concrete and very few Nano materials have been explored in the application of concrete.

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