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Assessment of the effect of Nano particles on physical and mechanical properties of high grade self-compacting concrete

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ABSTRACT

Concrete that can be poured and compacted under its own weight with little to no vibration and without bleeding or segregation is known as self-compacting concrete (SCC). The use of SCC in concrete manufacturing is growing daily due to its improved production techniques. Recently, nanoparticles have gained greater interest due to their unique physical and chemical properties, and they are being exploited in many different fields to develop novel materials with creative uses. . Using a logical mix design, M60 grade self-compacting concrete was created in this project. 1%, 1.5%, and 2% of nano silica in a colloidal condition with 30% nano content was added to SCC. To support the novel features of SCC, tests such as the L-box, V-funnel, J-Ring, and slump flow were carried out and compared to the EFNARC (2005) requirements. Compressive, split tensile, and flexural strengths are among the strength characteristics of M60 grade SCC at 3, 7, and 28 days, both with and without nanoparticles (SiO). In comparison to the SCC without nanoparticles, it was determined that the SCC with silica nanoparticles exhibited superior strength characteristics. According to test results, adding nanoparticles to concrete has enhanced its performance in a number of strength-related areas.

Keywords: *self-compaction, durability, strength behavior, nano silica, and partial cement replacement of cement, Durability*.

1. INTRODUCTION

Self-compacting concrete, has garnered a lot of interest since it was first created in Japan in the late 1980s by Okamura to construct durable concrete structures. SCC is now frequently used for insertion in tightly packed reinforced concrete structures with challenging casting circumstances. Fresh concrete needs to be exceptionally cohesive and fluid for these uses. SCC is defined as a concrete that is cohesive enough to handle without segregating or bleeding, but is still able to be poured and compacted on its own weight with little to no vibration effort.It is employed to guarantee the proper fill-out and structural soundness of heavily reinforced structural components.SCC development is a desired achievement in the construction industry to overcome issues related to cast-in-place concrete. SCC may be pushed farther because of its high fluidity and resistance to segregation. It is also unaffected by the layout of the structure, the quantity and type of reinforcing bars, and the skill levels of the workers.

Faster construction schedules and dependable compaction in the structures—particularly in confined areas where vibration and compaction are challenging—are the primary benefits of SCC. Professor Hajime Okamura introduced the idea of SCC in 1986, but it was Professor Ozawa of the University of Tokyo who actually constructed the first prototype in Japan in 1988. At that time, SCC was created to increase the lifespan of concrete constructions. Since then, more studies have been conducted, and SCC has been applied to real structures in Japan, primarily by sizable construction firms. From the perspective of standardizing concrete, research has been done to offer a way to confirm its self-compactibility and a logical approach to mix design. Compaction does not require any additional internal or external vibration because of the way SCC is cast. After putting, the surface is incredibly smooth and slides like "honey." The same ingredients that make up conventional concrete—cement, aggregates, and water—as well as varying amounts of mineral and chemical admixtures make up SCC. When compared to regular concrete, these concretes typically have better mechanical qualities, are easier to work with, and/or are more resistant to chemical degradation.Self-compacting concrete, or SCC, is concrete that can flow and compact under its own weight without the need for mechanical vibration. It is a highly sought-after feature in the construction industry because of its superior surface finishes, simplicity of installation, and reduced labor costs. Superior SCC traits are strength-to-cardiac endurance attributes that are superior. Stability and flowability are the two main qualities of SCC in its plastic state that distinguish it.High range water reduction admixtures (HRWR) are commonly utilized in the production of SCC due to its exceptional flowability.The stability to segregation of the plastic concrete mixture is accomplished by increasing the total amount of particles in the concrete.

2. LITERATURE REVIEW

The main objective of the work is to build an SCC (M60grade) and understand how the strengths of such an SCC change based on the % of nanoparticle addition, as is clear from the current discussion. Below is a detailed discussion of the literature on this subject. The usage of self-compacting concrete was not well known to the general public in the early 1990s, and when it was, it was primarily in Japanese. In January 1989, Ozawa gave the first paper on self-compaction concrete at the second East-Asia and Pacific conference on structural engineering and construction. Following that, self-compaction concrete attracted the attention of scientists and engineers worldwide who are interested in the long-term viability of concrete as well as sensible building techniques. The first international workshop on self-compaction concrete was held in Kochi, Japan in August 1998, following the formation of RILEM's committee on the subject in January 1997. A significant quantity of literature research is done in this area because the investigation's goal is to create and investigate the characteristics of self-compacting concrete, as explained below.

Hajime okamura (1997): Okamura designed a novel kind of concrete that can be crushed into every crevice of a formwork using only its own weight.He began investigating the workability and flow characteristics of this unique variety of concrete—later dubbed self-compacting concrete—in 1986. The properties of the constituent elements and the ratios of the mixture can have a significant impact on this concrete's self-compactibility. In his research, Okamura (1997) set the fine aggregate content at 40% of the mortar volume and the coarse aggregate content at 50% of the solid volume.

Kazumasa ozawa (1988): He was able to create SCC for the first time. The next year, over a hundred researchers and engineers witnessed an open experiment on the novel kind of concrete at the University of Tokyo. As a result, extensive study has started in a number of locations, most notably the University of Tokyo and the research centers of major construction enterprises.Ozawa finished the first self-compacting concrete prototype with readily available materials. Through the application of several superplasticizers, he investigated the workability of concrete and created an extremely workable concrete. It possessed excellent permeability and was appropriate for quick placement. The V-funnel test was used to determine the concrete's viscosity.

Domone et al (1999): has conducted research on the impact of four distinct super plasticizer kinds and diverse powder combinations, such as Portland cement, GGBS, fly ash, micro silica, and lime stone powder, on the initial characteristics of the SCC mortar phase. He came to the conclusion that testing on mortars could evaluate a number of significant factors that affect SCC performance. This includes comparing the effectiveness of various super plasticizers, examining the effects of adding the super plasticizer at different times throughout the mixing process, and examining the workability and retention qualities of mixes that contain binary and ternary blends of powder.

3. OBJECTIVE OF CURRENT STUDY

This study looked into how performance-related features like strength variations of M60grade SCC could be enhanced by adding nanoparticles, such as nanosilica (SiO_2), using a modified Nansu method (rational mix design) that satisfies both fresh and hardened properties in accordance with EFNARC specifications. To assess the new features, tests such as the T50, L-box, J-ring, V-funnel, and slump flow tests were conducted. To assess the strength characteristics, flexure, split tensile, and compressive strength tests were conducted.

- Analyze the effects of various nanoparticles on the compressive strength of SCC, including silica, titanium dioxide, and carbon nanotubes.
- Ascertain how nanoparticles affect SCC's tensile and flexural strengths.
- Examine how nanoparticles affect SCC's workability and flow characteristics.
- Assess the permeability and chemical resistance of the nanoparticle-enhanced SCC in terms of durability.
- To improve the overall functionality of SCC, optimize the concentration and combination of nanoparticles.

4. MATERIALS USED

Materials and methods Ordinary Portland cement (OPC) that met ASTM C150 standards was used as received. The cement's physical and chemical properties are shown in Table 1. The OPC's particle size distribution pattern is displayed in Figure 1. Suzhou Fuer Import & Export Trade Co., Ltd. supplied the CuO nanoparticles, which had a Blaine fineness of 45 m2 g−1 and an average particle size of 15 nm. The properties of CuO nanoparticles are shown in Table 2. CuO nanoparticle scanning electron micrographs (SEM) and powder X-ray diffraction (XRD) diagrams are shown in Figures 2 and 3. Two types of sand, 4/12 gravel, and crushed limestone aggregates were used to create self-compacting concretes. Aggregates with a very high fines content of 19.2% (particle size <0.063 mm) were classified as fine 0/2, while coarse 0/4 were classified as fine aggregates. Their main objective was to enhance the volume of small particles in order to make the new concrete more stable

The admixture used was Glenium C303 SCC, a polycarboxylate based on polyethylene condensate defoamed. Table 3 shows some of the physical and chemical properties of the polycarboxylate admixture used in this study. Two series of mixtures were prepared for the laboratory trials. The C0-SCC series combinations were created using cement, fine and ultra-fine crushed limestone aggregates (19.2% by weight of the latter), and 0%, 0.3%, 0.5%, 0.7%, and 1.0% by weight of polycarboxylate admixture, which was replaced by the appropriate amount of water for each specimen. The N-SCC series was built using CuO nanoparticles, which have an average particle size of 15 nm. The mixtures were created using a 1 weight percent polycarboxylate additive, with 1 to 5 weight percent of CuO nanoparticles used in place of cement. The superplasticizer was dissolved in water, and then the nano-CuO was added and forcefully stirred for three minutes. A small amount of nano-CuO can be uniformly distributed by the superplasticizer despite the fact that it is insoluble in water.

The different materials used in this investigation are

- 53 Grade Ordinary Portland cement
- Fine Aggregate
- Coarse Aggregate
- Super Plasticizer (CONPLAST SP430)
- Fly ash.
- Water
- Silica fume
- Nano Silica (30% nano content)

5. METHODOLOGY

To evaluate the compressive strength, standard 150 x 150 x 150 mm cube molds made of cast iron were employed for casting. To evaluate the split tensile strength, standard 150 x 300 mm cast iron cylinder molds were used for casting. The flexural strength was tested using 100 x 100 x 500 mm standard prism molds. Installing the standard molds ensured that the mold plates were flush with each other. Plaster of Paris was utilized to fill in any little gaps. The molds were then kept and greased in order to get them ready for casting. After a 24-hour casting process, the specimens were demolded and transferred to a curing tank, where they were immersed in water for the necessary duration.

M60 grade concrete treated with nano silica but not nanoparticles is tested and cast as part of the program. Nine cubes, six cylinders, and six prisms were made without nanoparticles, out of the thirty-six cubes, twenty-four cylinders, and twenty-six prisms that were cast. For the purpose of adding nano silica (30% nano content) with additions of 1%, 1.5%, and 2% bwoc, 27 cubes, 18 cylinders, and 18 prisms were cast.12 cylinders, 12 prisms, and 18 cubes. While cylinders and prisms were tested for seven and twenty-eight days, cubes were tested at three, seven, and twenty-eight days. The specimen's

cast details are displayed in Table 3.1.

5.1 Mix proportions of SCC

Self-compacting concrete (SCC) benefits greatly from the exceptional workability of fresh concrete. The great flow ability, high stability, and low blockage of the SCC are due to its excellent fluidity, moderate viscosity, and cohesiveness. The amount of each ingredient in the combination determines this. Using the Self Compacting Concrete logical mix design approach, the proportions of the M60 grade SCC mix were established.

6. RESULTS AND DISCUSSIONS

This section presents and discusses the findings from the many strength tests that were conducted.

6.1 Effect of nano silica on Compressive Strength:

Table 4.1 and Fig. 4.1 provide specifics on the compressive strength of the M60 grade of SCC, both with and without nano silica. The figure unequivocally demonstrates that the nano silica concrete's compressive strength is substantially greater than that of the SCC concrete without nanoparticles. In other words, 1.5% micro silica is the optimal amount.

6.2 Effect of nano silica onsplit tensile Strength

Table 4.2 and Figure 4.2 display the split tensile strength of the M60 grade of SCC with and without nanoparticles and nanosilica. The figure unequivocally demonstrates that SCC without nanoparticles has a substantially higher split tensile strength than nano silica concrete. In other words, the optimal micro silica content is 1.5%

6.3 Effect of nano silica on flexural Strength:

Table 4.3 and Figure 4.3 provide specifics of the M60 grade of SCC's flexural strength both with and without nanoparticles and nanosilica. The flexural strength of nano silica concrete is not significantly greater than that of SCC without nanoparticles, as the figure makes evident. In other words, the optimal micro silica content is 1.5%

7. CONCLUSIONS

Following the experimentation, the following observations and conclusions were drawn.

The modified Nansu method was used in the current work to generate M60 grade SCC, and nano silica additions were made to it.

According to research, the compressive strength of self-compacting concrete made using admixtures like SP is increased when 1.5% nano silica is added. The maximum compressive strength of self-compacting concrete is attained at 1.5% nano silica addition, meaning that the compressive strength starts to decline at that point. The compressive strength rose by +11.77 percent after a 1.5% nano silica addition.

Compared to 1.5% and 1% nanosilica inclusion, 2% nanosilica inclusion in SCC will make the material less workable.

Consequently, it can be said that adding 1.5% nano silica will allow self-compacting concrete containing admixtures (SP) and silica fume to reach its maximal compressive strength.Thus, it is believed that a 1.5% addition of micro silica is ideal.

At 1.5% addition of nano silica, the split tensile strength increases by a percentage of +22.77.

When comparing nano silica concrete to SCC without nano particles, there is very little gain in flexural strength.

At 1.5% addition of nano silica, the percentage increase in flexural strength is +29.20.

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