Material Properties of Concrete Containing Nano silica, Alccofine and Polypropylene fibers

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Abstract

The strength properties of polypropylene fiber concrete partially substituting cement with an optimal combination of nano silica and alccofine 1203 are discussed in this research. The design mix utilised in this study was M25 grade concrete, with polypropylene fiber employed in varied proportions of 0, 0.1, 0.2, 0.3, and 0.4 percent in partial replacement of cement, and alccofine 15% and nanosilica 1% constant to total cement weight. For all mix quantities, the water binder ratio was 0.5. For the desired workability, superplasticizers were added using a trial and error procedure. On curing days for 28 days of concrete, the compressive strength, modulus of rupture, and modulus of elasticity were measured. The highest compressive strength, flexural resistance, and modulus of elasticity of the fiber reinforced concrete with alcofine and nano silica were 34.01 MPa, 8.5 MPa, and 29.22 GPa, respectively. Alcofine and nano silica concrete are compared to normal concrete in terms of strength.

Key words: Polypropylene fiber, Nano silica, alccofine, compressive strength, modulus of Rupture, Modulus of elasticity.

1.INTRODUCTION

Fiber reinforced concrete are going popularity day by day in the construction industry worldwide. The properties of concrete can achieved improvement by randomly oriented discrete fibers which prevent or control propagation or coalescence of cracks, the conventional concrete consisting hardened cement paste and aggregate has micro cracks and porosity which can overcome by using

fibers (1),such as polypropylene fibers, steel fibers, etc.., In this project polypropylene fibers were used and to increase the performance of concrete some mineral additives such as alccofine 1203 and nano silica were used. Nano silica possess higher pozzolanic nature compared to other nano filler materials, it forms additional C-S-H gel because of capability to react with free lime during the process of cement hydration, which improves the strength an durability of concrete (14). The optimum quantity of nano silica for concrete or cement paste cannot be fixed with certain percentage. It all depends on the type of nano silica and the average partice size of nano silica which can be expressed in terms of surface area to mass ratio. In this aspect a relationship should be established between optimum quantity and characteristics of nano silica (15). Because of the enormous amount of superplasticizer used to make UHPC, cement hydration is noticeably slowed. The inclusion of nano silica, on the other hand, can greatly counteract this retardation effect.(16).

Alccofine 1203 is a slag-based product that has been carefully processed to have a high glass content and increased reactivity. It is obtained through the granulation process, which produces a regulated distribution of particle size. Low calcium silicates make up the majority of the basic ingredients. the material is now being used in a number of major public and private projects in the structural and geotechnical domains. Alccofine has been studied by a number of researchers (7,8) who have found it to be an effective pozzolanic substance. Alccofine was found to increase concrete qualities, including resistance to acidic environments, sulphate attack, and chloride ion penetration.Alccofine is a GGBS ultrafine product with a lot of glass and a lot of pozzolanic reactivity. The use of alccofine ingredients increases not only the compressive strength of concrete, but also its fluidity and workability (9) When compared to control concrete, fibre reinforced concrete with alccofine had better durability and strength properties. In Binary Blended Concrete, 15% of the cement was substituted by Alccofine, which offered optimal workability and strength (10,11), Alccofine 1203 can be used to make high-strength concrete in two ways: as a cement replacement and to improve the qualities of the concrete. It lowers the cement content, which reduces costs, while also lowering the temperature rise (12).

The addition of polypropylene fiber significantly increased the flexural strength of the samples. When 0.3 percent PPF was added to mixes containing 10% Rice Husk Ash and 1% Nano Alumina, the 28- and 90-day strengths increased by 18.6% and 23.1 percent, respectively (2) The splitting tensile strength of concrete mixtures increases as the fiber content increases. Flexural strength is seen to grow as the level of fiber increases (3). The mechanical properties decreased by more then 0.6% polypropylene fiber inclusion, due to the non-uniform dispersion of fiber leading to a mass

collection that forms weak points working like voids and hence weakening the concrete strength (4). the influence of nano silica and alccofine impress mechanical properties, it helps restricting the entry of unwanted substances such as air, water and other chemicals into the concrete through increasing the strength and durability (5).The impact of polypropylene fibre on the mechanical properties of concrete containing nano silica and Alccofine has therefore been investigated.

Fig.1 cement

Fig.2 Aggregate

Fig.3 Polypropylene fiber

Fig.4 Nano silica

Fig.5 Alccofine

2.EXPERIMENTAL INVESTIGATION

Preliminary testing of the constituent materials used in the preparation of several proportions of polypropylene fiber reinforced concrete combinations was conducted. For this work, cubes, cylinders, and prism specimens were made. Compressive, flexure strength and modulus of elasticity are all being investigated. 6 different polypropylene fiber reinforced concrete mixtures were tested for strength. The components include substituting nano silica and alccofine with in varied proportions of 0, 0.1, 0.2, 0.3, and 0.4 percent in partial replacement of cement. The casting took place a standard curing method was followed with extreme caution. In at 28 days, three specimens from each instance were tested.

Nomenclature

OPC - Ordinary Portland Cement

NS- Nano Silica

AF- Alccofine

PPF- Polypropylene fibres

CC- M25 Grade Conventional Concrete

M1 - Mix with 5% Alccofine and 1% Nano silica replacement of cement.

M2 - Mix with 10% Alccofine and 1% Nano silica replacement of cement.

M3 - Mix with 15% Alccofine and 1% Nano silica replacement of cement.

M4 - Mix with 20% Alccofine and 1% Nano silica replacement of cement.

M5 - Mix with 25% Alccofine and 1% Nano silica replacement of cement.

NAPF0- Mix with 0% PPF and 15% Alccofine and 1% Nano silica replacement of cement

NAPF1- Mix with 0.1% PP and 15% Alccofine and 1% Nano silica replacement of cement,

NAPF2- Mix with 0.2% PPF and15% Alccofine and 1% Nano silica replacement of cement,

NAPF3- Mix with 0.3% PPF and 15% Alccofine and 1% Nano silica replacement of cement

NAPF4- Mix with 0.4% PPF and 15% Alccofine and 1% Nano silica replacement of cement,

2.1 Materials

2.1.1. cement

Ordinary Portland cement of 53 grade was used. OPC Dalmia 53 grade conforming to "IS12269 : 2013" are used in concrete.(5)

Table 1: Physical Properties of Cement

Property	**Value**
Specific gravity	3.15
Initial setting time	60mins
Final setting time	320mins

2.1.2. Aggregates

Fine Aggregate

Locally available river sand collected from kollidam river bed. it was partially replaced a M-Sand, several trial combinations of river sand and M sand are obtaining specific gravity of sand.

Finally found a 45% of M sand attains Specific gravity of 2.66. Conforming to Zone-II was governed by IS383- 2016.

Coarse Aggregate

Crushed granite aggregate conforming to IS 383-2016 with a maximum particle size 20 mm and 12mm has been used. The specific gravity of coarse aggregate was 2.72.

2.1.3. Alccofine

Alccofine is a mineral admixture a low calcium silicate microfine material based on blast furnace slag with high reactivity. It sourced from Aastrachemicals, Chennai. It can be used as a cement replacement to improve concrete properties. Physical properties of alccofine 1203 is shown in table 2.

Table 2: Physical Properties of Alccofine

Properties	**Values**
Particle size	6 microns
Specific gravity	2.90
Specific surface area(cm^2/g)	12000

2.1.4. Nano silica

Nano silica is a series of silica based filler obtained from Aastra chemicals, Chennai, the properties of nano silica shown in table 3.

2.1.5. Polypropylene fibers

Polypropylene fiber are polymer fibers, according to (8) fibers are straight oriented or deformed fragments and cut materials. There are two types of polypropylene fiber, such as microfibers and macrofibers.in this project microfibers are used. Microfibers are shorter than 30mm and the role of the microfibers are to overcome plastic shrinkage and limit the function of cracks, Properties of polypropylene fiber are shown in table 4.

Table 3: Physical Properties of Nano silica;

Properties	**Values**
Particle size	17 nm
Specific gravity	2.2
Colour	white
Specific surface area	160 m^2/gm

Table 4: Physical Properties of Polypropylene Fibers

Property	Value
Length	12mm
Shape	Triangular
Effective Diameter	40 microns
Specific Gravity	0.91
Tensile Strength	4 MPa
Elongation	90%
Elasticity Modulus	4000 MPa
Alkaline Stability	Very good

2.2. Mix Proportion

Concrete mix were designed to a compressive strength of M25 grade with water binder ratio of 0.5 as per the code IS10262 – 2019. The proportion of constituent material for concrete mixes are presented in Table 5.

Table 5: Mix Proportion

Mix Proportion	1 : 1.96 : 3.56
Cement	350 Kg/m^3
Fine Aggregate	687 Kg/m^3
Coarse Aggregate	1245 Kg/m^3
Water Content	175 Kg/m^3

W/B Ratio	0.50 %

2.3. Specimens

Concrete specimens of cube 18 Nos of size (150mm length, 150mm breadth, 150mm depth) were cast to test the compressive strength, 18 Nos of prisms specimens of size (100mm width, 100mm height, 500mm length) were cast to test the flexure strength and 18 Nos of cylinder specimens of size (150mm diameter and 300mm height) were cast to test the modulus of elasticity.

2.4. Test Methods

Compression test

Compression test was conducted on cube specimens in compression testing machines. Three samples of each mix were tested at 28 days of normal curing and average value was taken as final reading.

Fig 6. Test setup for cube specimen

Fig 7. Test setup for cylinder specimen

Water Absorption Test

The water absorption is directly related to durability as it is always exposed to several environmental conditions. The water absorption test is done on 150 mm polypropylene fiber concrete cubes, casted and water cured for 28 days as per ASTM: C1403 – 13. Experimental setup is shown in Fig. 8.

Fig8. Test Setup for Water Absorption

3. Experimental Results and Discussions

3.1. Determining the Optimal Alccofine and Nano silica percentages

The high pozzolanic character of alccofine and nano silica, as well as their filling capabilities, significantly improves concrete strength. The compressive strength of five mixes at 28 days of age was steadily increased up to an optimum replacement level of 15 percent and subsequently dropped. M25 grade with 15 percent Alccofine with 1 percent nanosilica had a maximum 28-day cube strength of 34.04 N/mm2. The optimum proportion of alccofine and nano silica is shown in Table 6.

Table 6 :Calculated optimal alccofine and nano silica amount for compressive strength

S.No	**Average compressive strength of 28 days (N/mm²)**
Mix 1	31.35
Mix 2	32.80
Mix 3	34.04
Mix 4	32.86
Mix 5	31.25

3.2 Effect on compressive strength

On cube specimens, compressive strength tests were performed. Table 7 shows the compressive strength values of the various combinations. Figure 9 shows the compressive strength of specimens with fibers added. The control specimen had a lower compressive value than the other

ternary blended with fiber reinforced mixes, according to the data. The addition of fibers and the ternary combination of nano silica and alccofine resulted in increased strength. Despite the fact that fibers are primarily used to improve toughness, impact resistance, and flexural properties, they can also improve compressive strength by preventing crack propagation, as evidenced by the strength results shown in Fig. 9 and the fact that the ternary blended mix had a significant strength increase.The NAPF3 specimen had a stronger gain in strength of roughly 17.52 percent than the Control specimen. Although the strength values of the other specimens were lower than those of NAPF3 it is clear that all of the strength values have exceeded the intended mean strength of M25 grade concrete. The combined action of nano silica filling pores, alccofine's pozzolanic reaction, and the presence of polypropylene fibers which prevented the crushing of concrete particles all contributed to improved strength.The strength of the NAPF0 and NAPF4 specimens decreased when compared to the NAPF3 specimen. This was due to the minor and major replacement levels of 0.1% and 0.4% respectively. While the 0.1% replacement level did not provide the necessary bonding properties as the majority may have dissolved, The greatest Addition of PPF 0.4 percentage was unable to produce the same level of binding as cement. However, the arresting of cracks with fibers and the plugging of pores with nano silica ensured that the strength did not fall below the required mean strength. Figure 10 and 11 shows the failure pattern of cubes and cylinder respectively.

Table 7: Compressive Strength of cubes and cylinders

Mixes	**Average compressive strength of 28 days of cubes (N/mm^2)**	**Average compressive strength of 28 days of cylinder (N/mm^2)**
CC	33.02	26.52
NAPF0	35.19	28.52
NAPF1	36.59	29.72
NAPF2	38.95	31.18
NAPF3	41.26	33.00
NAPF4	37.35	30.10

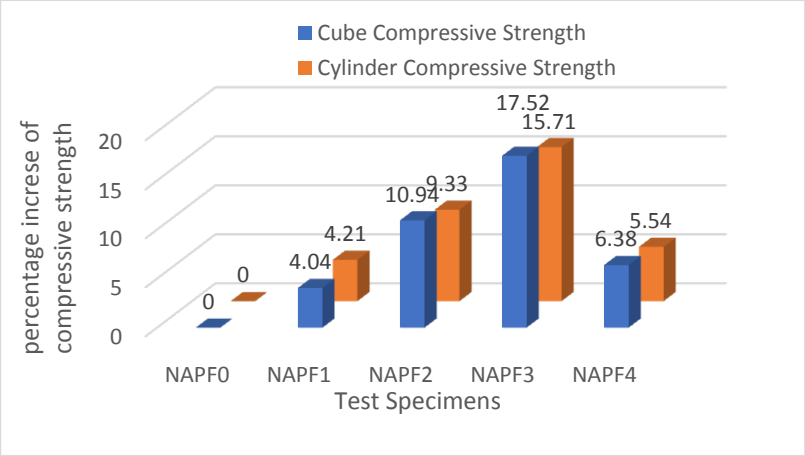

Figure9. Effect Of Polypropylene Fiber on Compressive Strength of Cubes and Cylinder

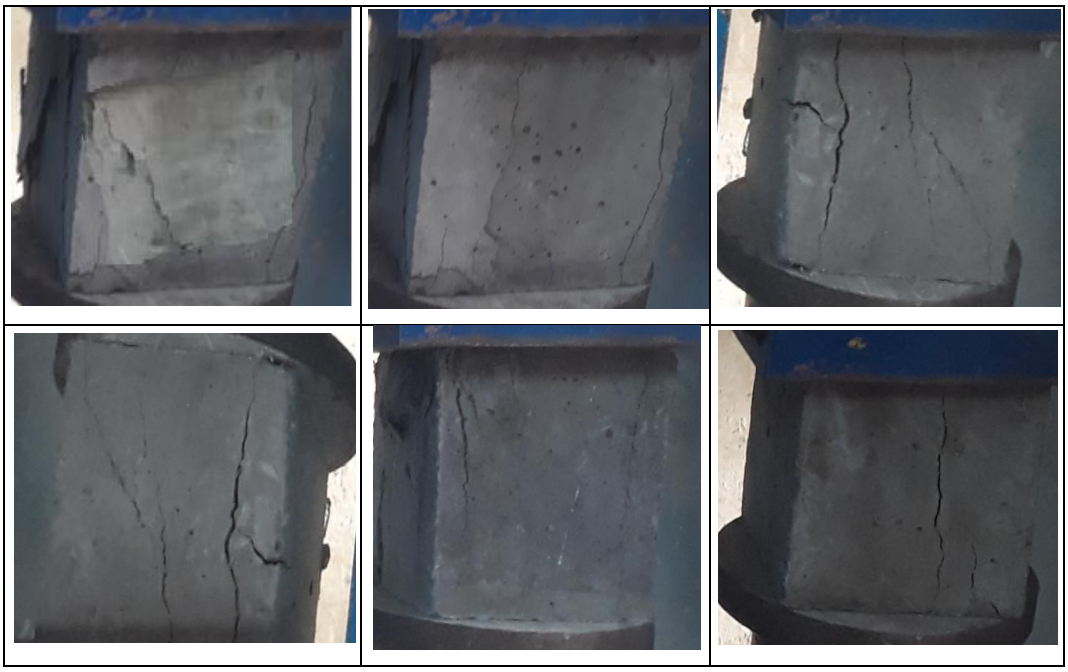

Figure 10. Failure Modes of Cube Specimen Under Compression Testing

Figure 11. Failure Modes of Cylinder Specimen Under Compression Testing

3.3. Water Absorption

Table 8 shows the water absorption test results for all of the specimens. Figure 12 depicts the effect of fibres on water absorption. When compared with control concrete, water absorption decreased by 0.29 percent, 0.25 percent, 0.21 percent, 0.19 percent, and 0.15 percent in specimens NAPF0, NAPF1, NAPF2, NAPF3, and NAPF4. The test results showed that as the fibre volume percentage increased, water absorption decreased. This could be due to pore blockage and decreased permeability.

Table 8 Water Absorption

Test Specimen	Intialwt	Final wt	Percentage of weight gain
CC	9054	9082	0.31
NAPF0	8243	8267	0.29
NAPF1	8457	8478	0.25
NAPF2	8469	8487	0.21
NAPF3	8583	8599	0.19
NAPF4	8067	8079	0.15

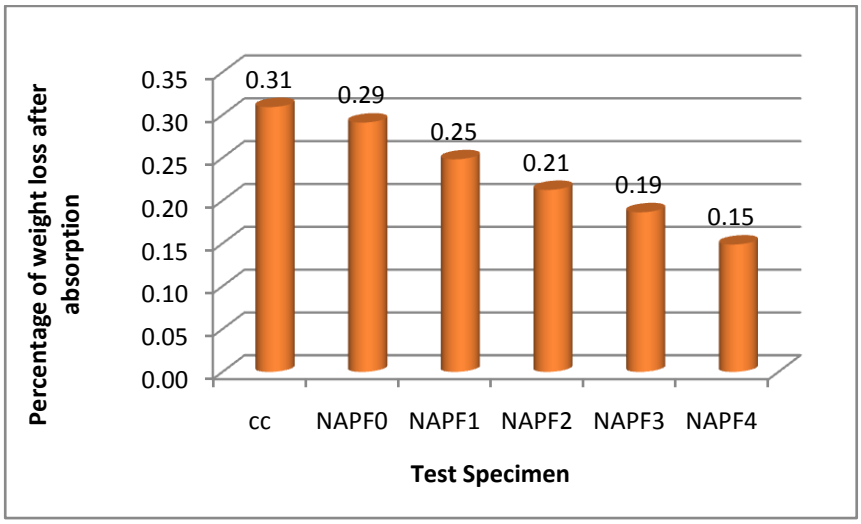

Fig.12 Effect of Fibres on Water Absorption

Conclusion

Extensive experimentation was carried out to determine the combined effect of Nano silica,Alccofine and Polypropylene fibre on compressive strength of concrete and Water Absorption

at watercementratio of 0.50, andcementreplacementof 15%Alccofine and 1% Nano silica.TheFollowing conclusions can be derived from the present study.

1.The compressive strength, of ternary mixed concrete were all increased by 6.57%, by adding 1% Nano silica and 15% alccofine.

2. The largest increase in compressive strength produced by the addition of 0.3% polypropylene fibre to ternary blended concrete was 24.12%.

3. Concrete's ability to absorb water is significantly reduced when polypropylene fibre is added to ternary blended concrete. The mixture with 0.4% polypropylene fibres has been determined to have the lowest water absorption of all the fiber reinforced concretes.

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