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RESEARCH ARTICLE

Experimental Investigation of Mechanical and Durability Properties of Concrete Containing Nano Silica, Alccofine and Polypropylene Fibers

MCK Jamenraja[1]*, **K Ravichandran**[2]

1 Research Scholar, Faculty of engineering and Technology, Annamalai University, Tamil Nadu, India
2 Associate Professor, Faculty of engineering and Technology, Annamalai University, Tamil Nadu, India

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* **Corresponding author**.

mckjamen93@gmail.com

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Abstract

Objectives: To evaluate the strength and durability behaviour of concrete specimens that have been reinforced with micro reinforcements made of polypropylene fibers and microfillers and nanofillers such as alccofine and nanosilica, respectively. **Methods**: The concrete samples were made to achieve a targeted strength of 33 MPa. In this experiment, polypropylene fibers were added to the concrete mix in volume fractions of 0%, 1%, 0.2%, 0.3%, and 0.4%, with the optimum percentages of alccofine (15%) and nanosilica (1%). Concrete mixes with and without PP fibers were evaluated for their mechanical properties, such as compressive strength, elastic modulus, and flexural strength and also looked at several durability characteristics, including acid resistance, porosity, sorptivity, and water absorption. The proper instrumentation has been used to make the measurements related to the experimental parameters. **Findings:** After the introduction of Alccofine, Nanosilica, and Polypropylene fibers, the following properties have been improved: compressive strength, elasticity modulus, flexural strength, water absorption, porosity, sorptivity, and acid resistance. Adding polypropylene fibers increased the compressive strength of cubes and cylinders by up to 15.15 and 14.87 percent, respectively. It also increased flexural strength by up to 10.47% and elasticity modulus by up to 14.35%. **Novelty:** The novel material, comprising polypropylene fibers, significantly enhances the mechanical and durability characteristics of concrete, enabling the concrete to avoid brittle and rapid failure and instead experience a more ductile failure that enhances the durability and serviceability of the concrete.

Keywords: Alccofine; compressive strength; modulus of Rupture; modulus of elasticity; nano silica; polypropylene fibers

1 Introduction

Cement-related building materials are currently the most important ones, and this is expected to remain so in the future. In the context of natural construction, concrete is frequently the greatest single material element. The three main ingredients of concrete are cement, aggregate, and water. While making up only 12% of the mass of concrete, cement is responsible for 6-7% of worldwide CO_2 emissions and 93% of all embodied energy. In order to enhance the qualities of these materials in terms of cost, strength, and environmental impact, cement and concrete manufacturing has focused more and more on blended cements. Alccofine and nanosilica need to be thoroughly researched as a partial replacement for ordinary Portland cement, and the character differences need to be addressed. Concrete compressive strength is a measure of objective strength. Due to issues with extreme shrinkage and subsequent neat cement paste breaking, strength tests on this material are not conducted. In this work, the effects of alccofine and nanosilica substitution on fiber-reinforced concrete's mechanical characteristics are examined.

Nanosilica has a higher pozzolanic nature compared to other nanofiller materials. It forms additional CSH gel because of its capability to react with free lime during the process of cement hydration, which improves the strength and durability of concrete[1]. The optimum quantity of nanosilica for concrete or cement paste cannot be fixed at a certain percentage. It all depends on the type of nanosilica and the average particle size of nanosilica, which can be expressed in terms of surface area to mass ratio. In this aspect, a relationship should be established between the optimum quantity and characteristics of nanosilica[2]. 1–2% of nanosilica improved the concrete strength[3]. Because of the higher percentage of superplasticizer used to make UHPC, cement hydration is noticeably slowed down. The inclusion of nanosilica, on the other hand, can greatly counteract this retardation effect.[4]. 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[5]. 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. Alccofine has been studied by a number of researchers[6] and[7] who have found it to be an effective pozzolanic substance. Alccofine was found to increase concrete qualities, including resistance to acidic environments, sulfate attack, and chloride ion penetration[8]. The influence of nanosilica and alccofine improves mechanical properties[9]. It helps restrict the entry of unwanted substances such as air, water, and other chemicals into the concrete by increasing its strength and durability[10]. A combination of 25% fly ash, 10% alccofine, and 1% colloidal nanosilica improved mechanical strength and water absorption[11]. The experimental studies on polypropylene fiber-reinforced concrete proved to be the best method or way of providing strong and durable concrete[1,12,13]. Incorporation of polypropylene fiber enhanced the flexural strength of samples remarkably[14,15]. The positive interaction between polypropylene fiber and rice husk ash resulted in the lowest shrinkage of mortars during drying[16,17]. Between the polypropylene fiber, aggregates, and cementitious materials, both the porosity and the pore size decrease with increasing fiber content[18], and the hydration-induced cracks are also reduced because of the high tensile strength of polypropylene fiber[19].

Sadiqul Islam GM et al[20] studied the evaluation of the correlation between compressive and splitting tensile strengths of concrete using alccofine and nanosilica. The authors determined the correlation between the compressive and splitting tensile strengths for all grades of concrete using regression analysis (power type equations). The authors observed good compliance between the experimental and analytical results. K. Ashwini et al[21] studied the effect of addition on the compressive strength of cement mortar cubes. The authors observed that early-age strengths were obtained for all the combinations, but 10% alccofine yielded more strength than other dosages. B. Sankar et al[22] studied the experimental and statistical investigation on alccofine-based ternary blended high-performance concrete. The authors reported that higher replacement levels of alcoofine (more than 10%) led to a decrease in strength due to the dilution effect. Denser particle packing reduces water absorption in ternary mixes.

Wide application of nanosilica and alccofine is found in eco-concrete mixtures, which are primarily made with the replacement of cement by waste materials. Low strength and a delay in setting time are the fundamental problems with eco concrete. These issues can be resolved by the use of mineral admixtures. It may be applied to oil well cement, which increases the strength and reduces the setting time.

In this study, the aim is to improve the mechanical and durability properties of fiber-reinforced concrete containing alccofine (15%) and nanosilica (1%). Different percentages of polypropylene fiber were used in the volume fractions of 0.1%, 0.2%, 0.3%, and 0.4%. To improve the mechanical and durability properties of concrete, alccofine and nanosilica were added to concrete containing different percentages of fiber. Compressive strength, flexural strength, modulus of elasticity, water absorption, sorptivity, porosity, and acid resistance tests were carried out, and the experimental results of specimens made with fiber were compared with those of the control specimens.

2 Methodology

2.1 Experimental Investigation

The experimental investigation has been carried out in two stages. In the first stage, different proportions of alccofine and nanosilica were used to partially replace cement in order to determine their optimal combination. In the second stage, polypropylene fibers were added to concrete in varying volume fractions (0.1, 0.2, 0.3, and 0.4 percent) with the optimal amount of alccofine and nano-silica. Mechanical and durability property tests were performed on the ternary blended concrete to determine its compressive strength, flexural strength, elasticity modulus, percentage of water absorption, porosity, and sorptivity.

Table 1. Properties of Concrete Materials Used in this study

S.No	Property	Value
Cement- Ordinary Portland Cement		
1	Specific gravity	3.15
2	Initial setting time	60mins
3	Final setting time	320mins
Fine Aggregate- River sand & M-Sand		
1	Specific gravity	2.67
2	Grading zone	II
Coarse Aggregate – 20mm & 12.5mm		
1	Specific gravity	2.72
2	Water Absorption (%)	0.72
3	Shape	Angular
Alccofine		
1	Particle size	6 microns
2	Specific gravity	2.90
3	Specific surface area(m^2/g)	12
Nano silica		
1	Particle size	17 nm
2	Specific gravity	1.2
3	Colour	White
4	Specific surface area	160 ^{2}/gm

2.2 Materials Used

2.2.1 Cement

The cement used in this study is shown in Figure 1. Ordinary Portland Table cement of 53 grade was used. OPC Dalmia 53 grade conforming to "IS12269: 2013" [23] was used in concrete. The properties of cement used are given in Table 1.

2.3 Aggregates

2.3.1 Fine Aggregate. Locally available natural river sand (55%) and M-sand (45%) combine conforming to the requirements of IS 383:2016 [24] was used as fine aggregate. The specific gravity of combined fine aggregate was 2.67. The properties of fine aggregate used are presented in Table 1.

2.3.2 Coarse Aggregate. Crushed granite aggregate conforming to IS 383-2016 with a maximum particle size of 20 mm and 12 mm has been used. The specific gravity of coarse aggregate was 2.72. The properties of coarse aggregate used are given in Table 1. The aggregates used in this investigation is shown in Figure 1.

Fig 1. Materials used for this study. a) cement b) aggregates c) Polypropylene fiber d) Nano silica e) Alccofine

2.3.1 Alccofine

Table 1 shows the physical properties of Alccofine. It was procured from Aastra chemicals, Chennai. The alccofine used in this study is shown in Figure 1.

2.3.2 Nano Silica

The properties of nano silica are presented in Table 1. The nano silica used in this investigation is shown in Figure 1.

2.3.3 Polypropylene Fiber

The polypropylene fiber used in this study is shown in Figure 1. Introduction of fiber in concrete enhances the mechanical properties of concrete such as compressive strength and flexural strength., improves the ductility behavior of concrete and decreases the crack width, spacing of cracks through the fiber bridging effect. The properties of polypropylene fibers used are presented in Table 2.

Table 2. Properties of Polypropylene Fiber

S.No	Property	Value
1	Length	12mm
2	Shape	Triangular
3	Effective Diameter	40 microns
4	Specific Gravity	0.91
5	Tensile Strength	4 GPa
6	Elongation	90%
7	Elasticity Modulus	4000 GPa
8	Alkaline Stability	Very good

2.4 Concrete Mix Proportion

The experimental part of this research work has been carried out by partially replacing cement with an optimum percentage of 15% alccofine and 1% nanosilica. According to IS 10262-2:2019[25], M25-grade concrete was produced. M25-grade concrete was used in this investigation, with a water-to-binder ratio of 0.5 for all the specimens. In accordance with Table 3, different concrete mixtures, including plain, ternary blended, and fiber concrete mixes, were cast. Due to the poorer workability of the fiber concrete mixes, the use of a superplasticizer was necessary to achieve the needed slump of 50 to 75mm. To achieve the desired slump range of 50 to 75mm, the superplasticizer Fosroc (CONPLAST-SP430) was dosed at up to 1% by cementitious material in the concrete mixer. It should be mentioned that the range of 50mm to 75mm was determined to be a desirable workable range for easy concrete placement without any congestion. Workability of all fiber concrete mixtures was sought in this range. The proportions of the concrete mix are presented in Table 3. The slump values of all the specimens were incorporated through graphs shown in Figure 2. With the reference of experimental observation noted that, specimens replaced with alccofine and nano silica have higher workability compared to control concrete.

Table 3. Concrete 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
Alccofine	15%
Nano silica	1%
Fiber	0.1 to 0.4%

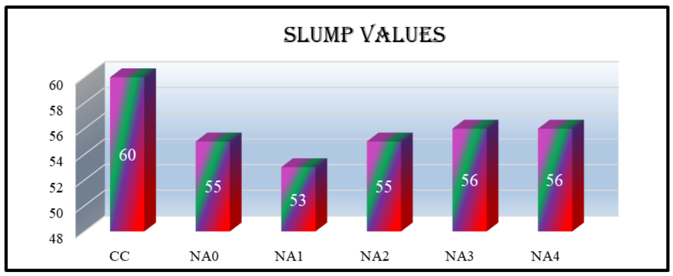

Fig 2. Slump values for all the specimens. In x-axis represents specimen ID for all mixes and y-axis represents slump value for all specimens

2.5 Test Specimens

The details of test specimens are presented in Table 4. The nomenclature of all the test specimens are given in Table 5.

Table 4. Details of concrete test Specimens

S.no	**Experiment**	**Specimens**	**No's**	**Size (mm)**
1	Compressive strength test	Cubes	18	150*150*150
		Cylinder	18	150*300
2	Flexural strength test	Prism	18	100*100*500
3	Modulus of elasticity	Cylinder	18	150*300
4	Water absorption	Cubes	18	150*150*150
5	Sorpitivity and Porosity	Cubes	18	150*150*150
		Disc	18	150*50
6	Acid Resistance	Cubes	18	150*150*150

2.6 Test Methods

2.6.1 Compression Test

The standard cube and cylinder specimens were tested in a Compression Testing Machine of 2000 kN capacity. The compressive strength experiments were performed as per IS 516:2004 [26]. The test set-up for this experiment is shown in Figure 3.

2.6.2 Flexural strength test

Flexural strength was calculated by conducting a four-point bending test on prism specimens in a testing machine as per code IS516:2004. The test set-up for this experiment is shown in Figure 3.

2.6.3 Elasticity Modulus Test

The standard cylinder specimens were tested in a compression testing machine of 2000 kN capacity. A compressometer is a device used in the compression test of the concrete cylinder to determine its strain and deformation characteristics. The results for each specimen type were based on the average value of three specimens from the same group.

Table 5. Nomenclature of Test Specimens

Specimen	Description
CB	Control Specimen
NAPF0	Specimen with 15% Alccofine and 1%Nano Silica (as partial replacement of cement)
NAPF1	Specimen with 15% Alccofine, 1%Nano Silica (as partial replacement of cement) and 0.1%Fiber (as added by volume of concrete)
NAPF2	Specimen with 15% Alccofine, 1%NanoSilica and 0.2%Fiber
NAPF3	Specimen with 15% Alccofine, 1%NanoSilica and 0.3%Fiber
NAPF4	Specimen with 15% Alccofine, 1%NanoSilica and 0.4%Fiber

2.6.4 Water Absorption Test

According to ASTM C642-97, a total of 18 cubes measuring 150 mm x 150 mm x 150 mm (CC, NA0, NA1, NA2, NA3, and NA4) were evaluated for water absorption. Each number is the average of three specimens from the same group. Initial masses of specimens (A) were measured using the weighing machine, and specimens were immersed in water. After 48 hours, the specimen has been taken out, and the saturated mass of the specimen (B) has been measured. The test setup for water absorption is shown in Figure 3. The water absorption was determined by using the formula.

Water absorption (%) =(B-A/A) *100

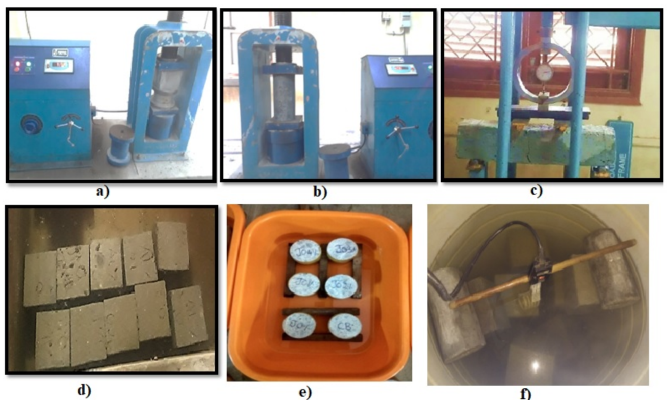

Fig 3. Test Setup's of various specimens and tests. a)Test setup for cube specimen b)Test setup for cylinder specimen c)Test setup for Prism specimen d)Water Absorption e)Test Setup for Sorpitivity f) Test Setup for Porosity

2.6.5 Sorpitivity Test

According to ASTM C1585-04, a total of 18 specimens measuring 100mm in diameter and 50mm in length were examined for capillary rise of water. The average result of three specimens from the same group is represented by each value. The test setup is shown in Figure 3. The initial weight of the specimens was measured using a weighing machine. Fill the specimens with water up to 5 mm thick in a suitable container. Start the timing device, measure the specimen weight every hour, and record the reading. Continue the measurements up to 6 hours.

The sorptivity is determined by using the formula I=m/(a/d)

Where, I= the absorption in mm, m= the changes in specimen weight at time(t), a= the exposed area of the specimens (mm^2), d= the density of the water(g/mm^3).

2.6.6 Porosity

A porosity test was carried out as per ASTM C642-97. The specimens were placed in a suitable receptacle, immersed in water, and boiled for 5 hours. The test set-up is shown in Figure 3. The specimen mass was determined after removing the surface moisture. The soaked, boiled, and surface-dried mass was found (C). The porosity was determined by using the formula

Volume of permeable pore space (Voids), %= (3-1)/(3-4)*100

Where, 1= Mass of dried specimen, 2 = Mass of surface dry sample in air after immersion, 3= Mass of surface fry sample in air after immersion and boiling, 4= Apparent mass of sample in water after immersion and boiling, ℓ= Density of water (g/cm^3).

2.6.7 Acid Resistance Test

A total of 18 cubes of size 150 x 150 x 150mm were tested for acid resistance as per ASTM C1012. The test set-up is shown in Figure 4. Each value represents the average result of three specimens in the same group. The initial mass of all the specimens was measured. The specimens were kept immersed in a 5% H_2SO_4 solution. After 28 days, the specimens were taken out, surface dried, and their masses were determined. All the specimens were tested in compression to assess the loss in strength.

Fig 4. Test Setup for Acid Resistance

3 Results and Discussion

3.1 Effect of fiber on compressive strength

The compressive strengths of specimens are provided in Table 11. The cube specimens NAPF0 exhibited an increase of 6.57% over the control specimen. The cylinder specimens NAPF0 exhibit an increase of 7.54% over the control specimen. The cube specimens NAPF1, NAPF2, NAPF3, and NAPF4 showed an increase of up to 4.04%, 10.94%, 15.71%, and 6.38% when compared to the NAPF0. The cylinder specimens NAPF1, NAPF2, NAPF3, and NAPF4 showed an increase of up to 4.21%, 9.33%, 17.52%, and 5.54%, respectively, when compared to the NAPF0. Figure 5 (a) shows the effect of fiber on cube and cylinder compressive strengths. Similar observations were made in previous works. In ref.[20], the addition of PP fibers to the concrete mix has a little effect on its compressive strength. With increasing fiber content, the compressive strength of concrete decreased slightly. The addition of fibers creates a larger interfacial transition zone in concrete, which might affect its compressive strength. The strength of cubes mainly depends on the percentage of alccofine based on its high pozzolanic nature to form a denser Calcium Silicate Hydrate (CSH) gel. Hence, it exhibits the addition of alccofine, proving that there is some significant contribution to cement in its strength[27]. The silica-rich SF reacts with portlandite to produce additional C-S-H gel, which progressively densifies the matrix, resulting in increased strength. AL replacement with cement rapidly increased strength due to its highly reactive components; the maximum value was observed for a 10% replacement[22].

Table 6. CompressiveStrength 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

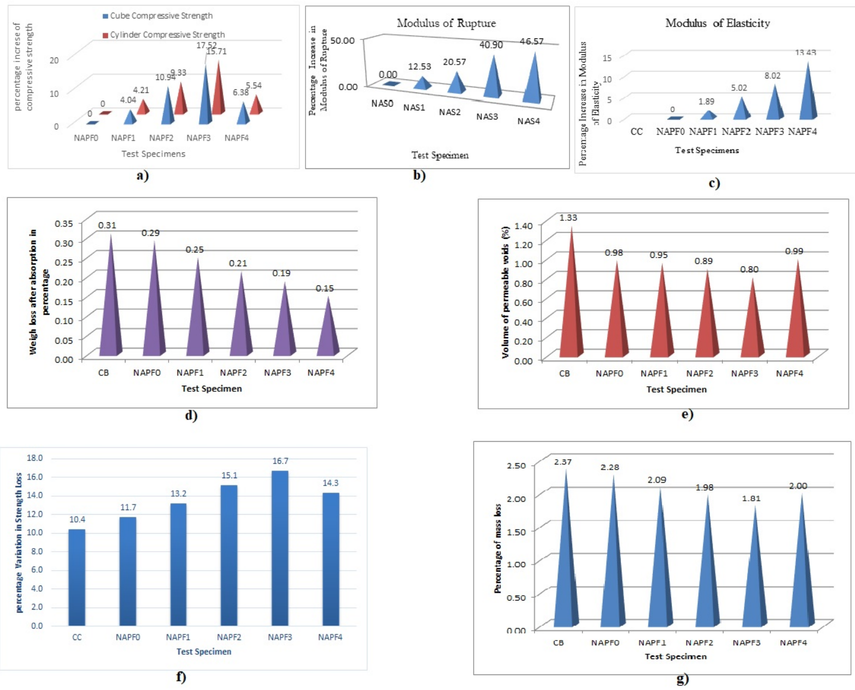

Fig 5. Effectof Polypropylene Fiber on a) Compressive Strength of Cubes and Cylinder b) flexural strength of prism c) Modulus of elasticity d) Water Absorption e) Porosity f) Acid Resistence – Strength loss g) Acid Resistance-Mass loss

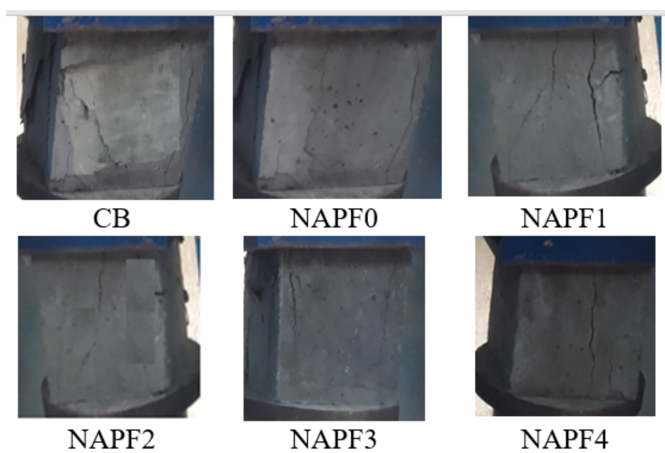

Fig 6. Failure pattern of cubes

Fig 7. Failure Pattern of Cylinders

3.1.2 Failure Mode

Figures 6 and 7 show the failure modes of cube and cylinder specimens subjected to axial compression. During failure, control specimens had some major cracks and a significant amount of concrete spalling, whereas specimens with 1% nanosilica and 15% alccofine had some minor cracks and a small amount of concrete spalling. There were no major cracks or concrete spalling in the specimens with polypropylene fibers.

3.2 Effect on Modulus of Rupture

Table 7 represents the effect of fibers on flexural strength. The prism specimen NAPF0 exhibits an increase of 5.22% when compared to control specimens. The prism specimens NAPF1, NAPF2, NAPF3, and NAPF4 showed an increase of up to 12.53%, 20.57%, 40.90%, and 46.57% when compared to the NAPF0. The flexural strength was found to increase with increasing fiber content. The effect of fiber on flexural strength is shown in Figure 5 (b) Similar effects were observed in previous works. In Ref.[(22)], the addition of pozzolanic materials into the concrete mix reduces calcium hydroxide concentration through the formation of secondary CSH gel, which then solidifies the interfacial bond between aggregates and paste in the matrix. The stronger the interfacial bond, the higher the flexural strength and resistance to crack propagation.

Table 7. Flexural Strength of Prism

Mixes	Average Flexural strength at 28 days (N/mm^2)
CB	4.02
NAPF0	4.23
NAPF1	4.76
NAPF2	5.10
NAPF3	5.96
NAPF4	6.20

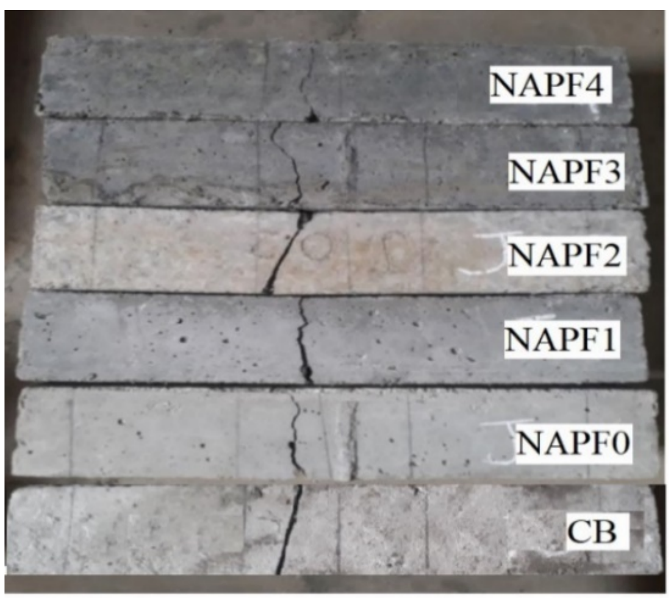

Fig 8. Failure pattern of Prism

3.2.1 Failure Mode of Prism

Figure 8 shows the failure mode of prisms. The cracks initiated at the bottom side of the prism and extended vertically at applied load. The test results observed that control concrete attained brittle failure and the specimens made with polypropylene fiber attained ductile failure through the bridging effect.

3.3 Effect on Modulus of Elasticity of Concrete

The elasticity modulus of cylinder specimens is presented in Table 8. The cylinder specimen NAPF0 exhibited an increase of 3.12% when compared to control specimens. The cylinder specimens NAPF1, NAPF2, NAPF3, and NAPF4 showed an increase of up to 1.89%, 5.02%, 8.02%, and 13.44% when compared to the NAPF0. The effect of fiber on modulus of elasticity is shown in Figure 5 (c).

Table 8. Modulus of Elasticity of Cylinder

Mixes	Average values of Modulus of Elasticity (E) Gpa
CC	29.73
NAPF0	30.66
NAPF1	31.24
NAPF2	32.20
NAPF3	33.12
NAPF4	34.78

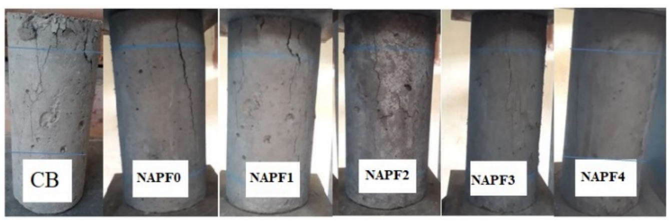

Fig 9. Failure pattern of Cylinder

3.3 1 Failure Mode

Figure 7 shows the failure mode of cylinder specimens. The tested specimens indicated that macrocracks were observed in control concrete, while multiple cracks were observed in concrete made with fiber.

3.4 Water Absorption

Table 9 shows the water absorption test results for all of the specimens. Figure 5 (d) depicts the effect of fibers on water absorption. When compared with control concrete, water absorption decreased by 0.29%, 0.25%, 0.21%, 0.19%, and 0.15% in specimens NAPF0, NAPF1, NAPF2, NAPF3, and NAPF4. The test results showed that as the fiber volume percentage increased, water absorption decreased. This could be due to pore blockage and decreased permeability. Similar works were observed in previous works. In ref.[(28)], the addition of nanosilica reduced the permeability because of its densified microstructure and refined pore structure . The addition of SF and AL densifies the matrix through the reduction of pores, which in turn reduces the ingress of water. The densification of pores is associated with the formation of secondary C-S-H crystals[(22)].

Table 9. Water Absorption

Test Specimen	Intial wt	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

3.5 Porosity

The porosity test results for all of the specimens are given in Table 10. The test result showed that as the fiber volume percentage in the concrete increased, the volume of permeability voids decreased. When compared to CC, specimens NAPF0, NAPF1, NAPF2, NAPF3, and NAPF4 exhibited a reduction of 0.98%, 0.95%, 0.89%, 0.80%, and 0.77%, respectively. This could be due to a decrease in pore inner connectivity and capillary porosity. Figure 5 (e) shows the influence of fibers on porosity.

Table 10. Porosity

Test Specimen	Initial Weight	Weight after immersion in water	Weight after boiling	Apparent Density	Volume of Permeable Voids (%)
CC	8542	8575	8580	2.56	1.13
AZ0	8568	8597	8601	2.56	0.98
AZ1	8277	8301	8307	2.47	0.95
AZ2	8460	8481	8489	2.53	0.89
AZ3	8522	8537	8549	2.53	0.80
AZ4	8471	8482	8495	2.53	0.77

3.6 Sorptivity

Sorptivity is the tendency of hardened concrete to absorb water by capillary action. The porosity of the concrete determines its sorptivity. Figure 10 depicts the results of the sorptivity test. Figure 10 depicts the absorption as a function of time. The integration of polypropylene fiber with nanosilica and alccofine showed less absorption than the control concrete. The polypropylene fiber works as a pore filler, reducing absorption. Concrete with a volume fraction of 0.3% PP fibers, 1% nanosilica, and 15% alccofine has a lower sorptivity than conventional concrete mixtures. When compared to control concrete, fiber concrete has a lower sorptivity coefficient. The use of PP fibers resulted in a considerable decrease in capillary pores and internal pore connectivity.

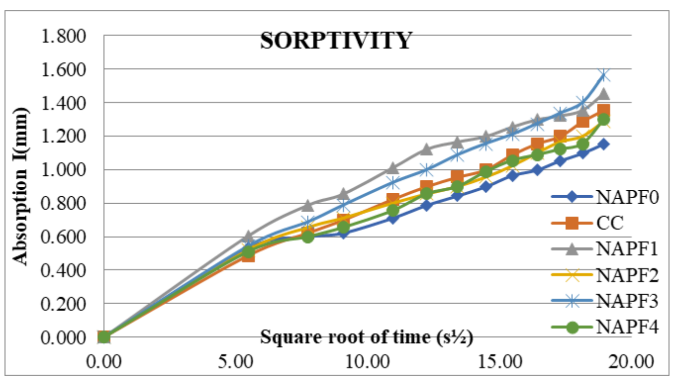

Fig 10. Sorptivity

3.7 Acid Resistance

The effect of fiber on strength is shown in Fig. 5(f) When compared to the CC, the concrete specimens NPF0, NAPF1, NAPF2, NAPF3, and NAPF4 showed an increase of 5.8 percent, 8.7 percent, 11.6 percent, 5.5 percent, and 1.6 percent, respectively. The comparison of compressive strength is presented in Table 11. The test results indicated that the increases in strength may be due to the addition of fiber. Fiber acts as a strong resistance to corrosion and chemical attack.

Figure 5 (g) shows the percentage of weight loss of specimens after immersion in acid. When compared to the CC, the specimens NAPF1, NAPF2, NAPF3, and NAPF4 lost 0.25%, 0.21%, compared to the CC, the specimens NAPF1, NAPF2, NAPF3, and NAPF4 lost 0.25%, 0.21%, 0.19%, and 0.15% of their weight, respectively. The weight loss in specimens made with fiber was less compared with specimens without fiber. This may be attributed to the inclusion of fiber in concrete. Fiber

Table 11. The comparison of compressive strength

Test Specimen	Avg. Compressive Strength Before immersion	Avg. Compressive Strength After immersion	Percentage of strength loss
CC	31.0	30.26	2.38
NAPF0	33.7	32.95	2.25
NAPF1	33.7	33.02	2.06
NAPF2	34.6	34.01	1.71
NAPF3	32.7	32.19	1.58
NAPF4	31.0	30.35	2.01

provides a strong bond between the cementitious material and aggregate matrix.

4 Conclusion

An experimental investigation examined the influence of polypropylene fiber, nanosilica, and alccofine on the mechanical and durability properties of concrete. The following conclusion can be drawn from the experimental results:

1. The compressive strength, flexural strength, and modulus of elasticity of ternary mixed concrete were all increased by 6.57%, 5.22%, and 3.12%, respectively, by adding 1% nanosilica and 15% alccofine.
2. A 51.85% increase in flexural strength and a 16.56% increase in elastic modulus were achieved by adding 0.4% of polypropylene fiber to ternary blended concrete. The largest increase in compressive strength produced by the addition of 0.3% polypropylene fiber to ternary blended concrete was 24.12%.
3. Concrete's ability to absorb water is significantly reduced when polypropylene fiber is added to ternary blended concrete. The mixture with 0.4% polypropylene fibers has been determined to have the lowest water absorption of all the fiber reinforced concretes.
4. As the percentage of fiber in the volume of concrete increases, the volume fraction of porosity decreased, and the volume fraction was 0.3%. The sorptivity of polypropylene fibers in ternary blended concrete is smaller than that of conventional concrete.
5. Fiber acts as a strong resistance to corrosion, chemical attack, so it increases the strength. The weight loss in specimens made with fiber was less.

Novelty: Nanotechnology applications have the potential to make breakthroughs in material technology. It will lead to performance-based material design for specific requirements. Using nanotechnology, it will be possible to design materials for their specific purposes.

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