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RESEARCH ARTICLE

Performance Evaluation of Fibre Reinforced Concrete Containing Alccofine and Zeolite

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Abstract

Objectives: The intent of the study is to assess the strength and durability behavior of concrete specimens attaining micro fillers such as alccofine and zeolite and micro reinforcement in the form of polypropylene fibres. **Methods:** Polypropylene fibres were added in volume fractions of 0%,0.1%, 0.2%, 0.3% and 0.4%. The mechanical properties of concrete such as compressive strength, modulus of elasticity and flexural strength were obtained for concrete mixes with and without PP fibres through standard testing procedure. Some durability properties such as water absorption, porosity, sorptivity, acid resistance were also examined. Appropriating instrumentation has been adopted for making the measurements pertaining to the above parameters. **Findings:** Introduction of micro fillers and polypropylene fibres caused a significant effect on as compressive strength, modulus of elasticity, flexural strength, water absorption, porosity, sorptivity, and acid resistance. The results indicated that inclusion of polypropylene fibers exhibit maximum increase of 15.15% and 14.87% has been realized in the compressive strength of cube and cylinder, a maximum increase of 10.47% in flexural strength and 14.35% in elasticity modulus through the inclusion of polypropylene fibre. **Novelty:** The article reveals that inclusion of micro fillers and polypropylene fibre reinforced concrete in public spaces is a promising practice, since they are impacted by adverse environmental conditions, suffer surface degradation, and are the target of vandalism. It is clear that using concrete with improved characteristics will be advantageous.

Keywords: Alccofine; Compressive Strength; Durability; Elasticity Modulus; Zeolite; polypropylene fibre

1 Introduction

Concrete is a man made construction materials. During the cement production larger amount of CO_2 emits into the atmosphere. Hence, to reduce carbondioxide, the mineral admixture have been used for supplementary materials. In this research exhibited a detailed view of utilization of supplementary materials to improve the mechanical and durability properties of concrete.

1.1 Research Background

In recent years, a significant shift has taken place in making concrete perform better under a variety of environmental conditions. Research studies are being made to manipulate the properties of concrete through the introduction of appropriate replacement materials for cement and aggregates. Micro-fillers became popular as a cement replacement material. A big basket of materials came into practice for the purpose. However, the early age strength is not encouraging with these materials, as they are not so reactive in the initial stages. But the performance of concrete improved appreciably and hence these materials continue to be in the forefront. A lateral thought is that the above-mentioned practical difficulty can be eased through the ternary blending of finer materials. The addition of fibre reinforcement is very beneficial in enhancing the crack resistance and energy capacity of concrete.

1.2 Motivation

The performance of concrete can be augmented appreciably through the ternary blending of materials. It has been found from the literature survey that the data available in this domain is limited. In this context, this research work has been undertaken to examine the effect of introducing polypropylene fibres on the material properties of concrete containing zeolite and alccofine.

During cement production large amount of CO_2 released into the atmosphere [1]. When supplementary materials added to concrete then the unreacted calcium and silica are reacting with water to form additional C-S-H gel , and hence improves the bonding between the cementitious matrix [2].

One mainstream strategy is used byproducts of other industries as raw materials in construction fields. Cementitious material is the most commonly utilized material for construction. Its manufacture often uses a lot of natural resources and contributes significantly to global greenhouse gas emissions. Better particle packing lesser requirement of binder in concrete. Enhanced particle packing decreased the porosity and hence increase the quality of interfacial transition zone [3]. There have been several efforts made to cut expenses, save energy, use natural resources as little as possible, reduce greenhouse gas emissions, and protect the environment. These encouraged the development of mineral admixtures as supplemental cementitious materials through active research and development activities. Cementitious materials are added to concrete mixtures for various reasons including improving mechanical properties and durability properties.

Furthermore, in this research the partially replaced cement with alccofine and zeolite in the concrete. Alccofine 1203 is a slag material byproduct of glass industry obtained through the controlled granulation process. 1203 is a series that represented a ultra-fine particle size. Due to this particle size, it requires the low water demand and decreases the permeability by the reduction of voids. Zeolite is a powdery form obtained through the volcanic ash when react with salt water. Zeolite is available in many countries and depending on type the properties are varied. Zeolites are having honey combed like structure with alumini-calcium-silicate. Zeolites are having lowest specific surface area than the cement and hence it fill the gaps between the concrete matrix through reducing voids and finally attaining the strength of concrete. Zeolite is a mineral made up of aluminosilicate. [4] Nowadays, zeolite used as replacing material for cement and it obtained through when volcanic ash reacts with alkaline water [5]. Addition of zeolite in concrete achieves the mechanical and durability properties Two types of concrete hygrothermal were studied i.e reference concrete (without admixture) and 40% of cement partially replaced by natural zeolite [6].

In the research study, the polypropylene (Recron 3s) fibre were used, they possess high tensile strength, low modulus of elasticity. The polypropylene fibre is widely used in construction industry. Due to its easy handling, low thermal conductivity and highly resistance to acid attacks and corrosion [7]. Wang et al investigated the effects of both basalt and PP fibres on high performance concrete. The authors concluded that using of single doped basalt or PP fibre the increases compressive strength, flexural strength and split tensile strength [8]. Improving mechanical properties of concrete, including tensile strength, flexural strength, toughness, ductility, modulus of rupture and energy absorption. The addition of fibre in concrete resulting in change of brittle behavior into a ductile material [9]. The addition of zeolite and polypropylene fibre increases 44% of compressive strength and 24% of tensile strength [10].

In Ref. [11], Manjunatha et al., studied the influence of PVC waste powder and silica fume on strength and micro structure properties of concrete. Replacement of cement with 8% silica fume is kept constant and PVC was varied in 5%, 10%, 15%,20%, 25% and 30%. The authors also studied the micro structure properties indicated that concrete prepared with 15% PWP improved calcium silicate hydrate gel compared to mix prepared with 20% PWP. The authors reported that use of 15% PWP dosage is more beneficial while using its partial replacement of cement along with fixed content of silica fume (8%).The authors reported that replacement of cement with 8% silica fume and 15% PVC waste powder, it is possibly to achieve mechanical properties comparable to that control specimens. The authors suggested that PWP can be safely used as partial replacement of cement and it will be more economical and environment friendly.

In Ref.[12], Manjunatha et al., studied the Engineering properties and environment impact assessment of green concrete prepared with PVC waste powder. In this investigation, concrete is prepared with industrial waste like PVC waste powder and ground granulated blast furnace slag. The authors replaced cement with 30% GGBS and varying percentage of PWP such as 5%, 10%, 15%, 20%, 25% and 30%. The authors suggested that blend of both PWP and GGBS upto 15% and 30% replacement as a substitute for OPC, helps in achieving better bonding among the constituents of concrete and densification of concrete. The authors observed that use of GGBS and PWP advances the densification of concrete, diminishes the formation of microcracks and voids. The authors suggested that sudden decrease in environmental loads like water consumption and mineral resource scarcity because of GGBS and PWP as a substitute for cement. This indicated that, by using industrial by-products, one can save natural resources and overcome the disposal challenge of industrial waste by-products.

In Ref.[13], Manjunatha et al., investigated that experimental study on the use of human hair as fibre to enhance the performance of concrete. The authors attempted to use naturally available chopped human hair as fibre in concrete to enhance the performance of concrete. The human hair used as fibre used in percentage of 0.5%, 1%, 1.5%, 2% and 3% by weight of cement in concrete. The authors reported that use of human hair as fibre indicated that enhances the better bonding between ingredients of concrete by exhibiting enhancement in properties up to 2.5% dosage of fibre.

In Ref.[14], Reshma T V et al., conducted that influence of alccofine and PP fibres on stabilization of soil. The alccofine are used in various percentage of 5%, 10%, 15%, 20%, 25% and 30% with fixed 1% PP fibres. The authors suggested that inclusion of these admixture in the soil has improved the strength and stability of soil against the absorption of moisture content. The authors concluded that 20% of alccofine attained the maximum strength and beyond this stage strength decreases slightly. The optimum proportion of alccofine for soil stability is 20%.

In Ref.[15], Ranjitha B.Tangadagi et al., studied role of mineral admixtures on strength and durability of high strength self compacting concrete. The authors reported that improvement in strength is owing to ultrafine particles of GGBS and alccofine, excess of lime present in GGBS and alccofine which reacts with the cement particles for calcium silicate hydrates gel formation and make concrete dense, strong and less porous. The authors also reported that improvement in flexural strength due to addition of mineral admixture improves packing density and structure and also the presence of iron content in GGBS and alccofine improves the strength. This combination not only reduce the cement consumption but also support environment and cost rationalization.

In Ref.[16], Reshma T.V et al., investigated influence of ZnO and TiO_2 on mechanical and durability properties of concrete prepared with and without polypropylene fibres. The zinc oxide used in various percentage of 1%, 2%, 3%, 4% and 5%. The titanium dioxide used in various percentage of 0.5%, 1%, 1.5%, 2% and 2.5%by weight of cement with and without PP fibres. The combination of ZnO and TiO_2 exhibited better bonding between the constituents material of concrete. The addition of fibres 0.6% by weight of cement exhibited better strength properties is comparison to mixes prepared without fibres. The authors reported that using of fibres with nano materials make concrete dense and better CSH gel formation may improved the strength and structural properties of concrete. The authors concluded that the optimum use of ZnO and TiO_2 is found to be 4% and 2% with and without fibres.

1.3 Challenge

It is very important to understand the mechanical and durability properties of PP fibre-reinforced ternary blended concrete involving zeolite and Alccofine. Hence, this study has been taken up.

1.4 Objective

The primary objective of this study is to assess the material properties of PP fibre-reinforced ternary blended concrete involving zeolite and Alccofine.

2 Methodology

1. Testing of all the constituent materials for their basic properties.
2. Casting and testing of PP fibre reinforced ternary blended concrete cube specimens for determining the compressive strength.
3. Casting and testing of PP fibre reinforced ternary blended concrete cylinder specimens for determining the modulus of elasticity.
4. Casting and testing of PP fibre reinforced ternary blended concrete prism specimens for determining the modulus of rupture.

5. Casting and testing of PP fibre reinforced ternary blended concrete specimens (cubes and discs) for examining their durability properties such as water absorption, porosity, sorptivity and acid resistance.

Research effort has been made to modify the concrete by introducing the micro reinforcement and replacing partially with fillers to make concrete eco friendly and more ductile.

2.1 Experimental Programes

Ordinary Portland Cement (OPC) 53 grade as per IS 12269-1989 was procured from Dalmia cement, India. A combination of river sand (55%) and M.sand (45%) with a specific gravity of 2.67 and conforming (IS 383:1970) to grading zone III was used as fine aggregate. The grain size distribution curve graph is shown in Figure 1. Crushed granite with a maximum particle size of 20mm with a specific gravity of 2.72 and confirming to (IS 383:1970)[17] was used as coarse aggregate. Potable water was used for preparing concrete and curing the specimens. Polypropylene fibre (Recron 3s fibres) was used in this study and conforming to ASTM C1116[16]. The properties of polypropylene fibre are presented in Table 1. A Mix design of M25 grade concrete as per IS456-2000 was used. A cement content of 262.5 kg/m^3, 52.5 kg/m^3 of Alccofine, 35 kg/m^3 of Zeolite and 378 kg/m^3 of fine aggregate (River sand), 309 kg/m^3 of fine aggregate (manufactured sand), 747 kg/m3 of 20mm coarse aggregate and 498kg/m^3 of 12mm coarse aggregate, with a 0.5 w/b ratio was used in this study and according to IS 10262:2019[13]. The properties of alccofine and Zeolite are presented in Table 2 . Conplast SP430, a sulphonated naphthalene formaldehyde-based super plasticizer, was used and it conforms to ASTMC494[15].

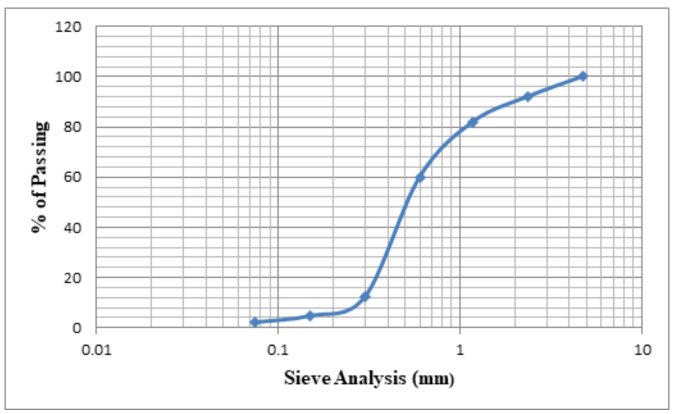

Fig 1. Grain size distribution curve for the combination of natural river sand (55%) and M. sand (45%)

Table 1. The properties of polypropylene fibre

Property	Value
Specific gravity	0.91
Aspect Ratio(L/D)	300
Tensile strength (MPa)	4
Young's Modulus (MPa)	4000

Table 2. The properties of Alccofine & Zeolite

Property	Alccofine Value	Zeolite Value
Specific surface area (m^2/g)	12.00	19.20
Specific gravity	2.94	2.66

2.2 Test Specimens and methods

Cube and cylinder specimens (3 for each mix) were tested according to IS 516:1959 in a Compressive Testing Machine of 200-ton capacity. Cylinder specimens (3 for each mix) were cast and tested as per IS 516:1959 in a standard testing machine of 200-ton capacity. Prism specimens (3 for each mix) were tested under four point bending in a standard loading frame of 50 kN capacity. The details of specimens are provided in Table 3. The nomenclature of all the test specimens are presented in Table 4. The average value for specimens of same groups for each test was presented. Cube specimens of size 150mmx150mmx150mm were cast and tested as per ASTM C642-97. Cube specimens of size 150mmx150mmx150mm were cast and tested as per ASTM C642-97. Cylinder specimens of size 100mmx50mm were cast and tested as per ASTM C1585-04. Cube specimens of size 150mmx150mmx150mm were cast and tested as per ASTM C1012.

Table 3. Details of specimens

Experiment	Specimen	Size(mm)
Compressive Strength Test (IS 516-1999)	Cube cylinder	150x150x150 150x300
Flexural Strength Test (IS 516-1999)	Prism	100x100x500
Elasticity Modulus Test (IS 516-1999)	Cylinder	150x300
Water Absorption Test (ASTM C642-97)	Cube	150x150x150
Porosity Test (ASTM C642-97)	Cube	150x150x150
Sorptivity Test (ASTM C1585-04)	Cylinder	100x50
Acid Resistance Test (ASTM C1012)	Cube	150x150x150

Table 4. Nomenclature of Specimens

Test specimen	Description
CC	Control specimen (M25 grade concrete)
AZ0	15% Alccofine + 10% Zeolite + 0% PP fibres
AZ1	15% Alccofine + 10% Zeolite + 0.1% PP fibres
AZ2	15% Alccofine + 10% Zeolite + 0.2% PP fibres
AZ3	15% Alccofine + 10% Zeolite + 0.3% PP fibres
AZ4	15% Alccofine + 10% Zeolite + 0.4% PP fibres

2.3 Water absorption and Porosity

A total of 18 cubes of size 150mm x150mm x 150mm (CC, AZ0, AZ, AZ2, AZ3 and AZ4) were tested for water absorption as per ASTM C642-97 Each value represents the average results of three specimens in same group. Specimen was immersed, cooling, dried, and mass determined in water at about 21^0 C or a minimum of 48h and until two consecutive mass values of the surface dried specimen at 24h intervals show a rise in mass of less than 0.5% of the larger value. The water absorption was determined by using the formula given by equation 1.

$$\text{Water Absorption } = (b - a/a) * 100 \quad (1)$$

Where, a = Mass of dried specimen, b = Mass of specimen after 48 hrs

As per ASTM C642-97, Porosity test was carried out. The specimens were placed in a vessel, immersed in water and boiled for 5hrs. The test set up is shown through Figure 9. The specimen mass was determined after removing the moisture. The soaked, boiled, surface dried mass was found (c) and the apparent mass of sample after boiling (d). The porosity was determined by using the formula given by equation 2

$$\text{Volume of Permeable Voids (\%) } = \left(\frac{c-a}{c-d}\right) * 100 \quad (2)$$

2.4 Sorptivity

A total of 18 specimens of size 100mm diameter and 50mm were tested for capillary rise of water as per ASTM C1585-04. Each value represents the average result of three specimens in the same group. The test set-up is shown through Figure 10. Measure the initial mass of specimen. Place the specimen at bottom of pan and fill the pan with water level upto 3mm. Start the timing device and record the measurements every hour. The readings was taken upto 6 hrs. The sorptivity is determined by using the formula given by equation 3.

$$I = m/(\frac{A}{\rho}) \tag{3}$$

Where, I = the absorption(mm), m = mass changes at time (t), A = area of the specimens(mm^2), ρ = Density of water(g/mm^3).

2.5 Acid Resistance

As per ASTM C1012, a total of 18 cubes sized 150mm*150mm*150mm were tested for acid resistance. 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 5% of H_2SO_4 solution. The specimens were taken out after 28 days, surface dried, and their masses determined. To determine the strength loss, all of the specimens were tested in compression.

3 Results and Discussion

3.1 Compressive Strength

An increase in compressive strength was observed in ternary blended concrete with and without polypropylene fibres in comparison with the control specimens. Each value represents average of the test result of three specimens. The percentage increase in compressive strength for cube specimen is shown in Figure 2. The cube specimens AZ1 and AZ2 showed an increase of 2.41% , 7.86% when compared to the AZ0. The cube specimens AZ3 and AZ4 showed an increase of 15.15% and 3.53% when compared to the AZ0.

The cylinder specimens AZ1 and AZ2 showed an increase of 3.11% , 7.76% when compared to the AZ0. The cylinder specimens AZ3 and AZ4 showed an increase of 14.87% and 6.72% when compared to the AZ0.

Figure 2 shows effect of polypropylene fibres on compressive strength for cubes and cylinders. Here, Graph represents that polypropylene fibre-reinforced ternary blended concrete specimens (15% Alccofine, 10% Zeolite, and fibres involved in the range of 0.1%–0.4%) were compared with specimens (AZ0) having no fibres.

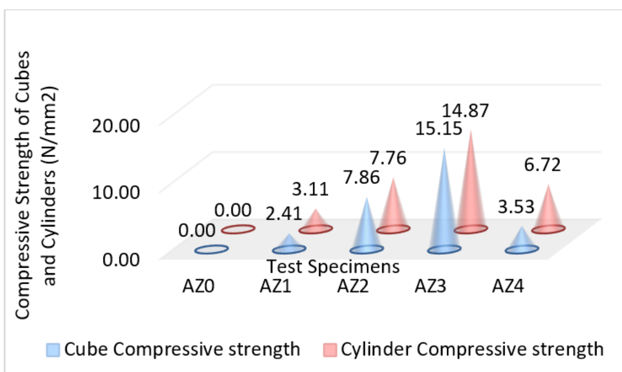

Fig 2. Effect of polypropylene fibreson compressive strength for cubes and cylinders

The test results clearly indicates that after the addition 0.3% of polypropylene fibre decreased the compressive strength. The same trend was reported by [7]. After the addition of 0.6% PP fibre the compressive strength decreased by increasing percentage of fibre. This reduction is due to non uniform allocation of fibre in concrete caused by unsuitable mixing. Hence, it detract the concrete density and compressive strength. A Narendra Reddy et al [2] experimented on concrete in which cement partially replaced by alccofine, GGBS and flyash. From the test results, the optimum replacement of 10% alccofine along with 25% flyash improved the strength. Gayathri [3] when 10% alccofine and 30% GGBS attained the good strength when compared to remaining mixes. In addition, of PP fibre is very fine material and the length variety of staple made a bridge action for preventing creations of micro cracks and easy dispersion of 3D network of fibres enhancing the compressive strength [7]. The percentage increases in compressive strength for cylinder specimen is shown in Figure 2. This increase may be due to inclusion of fillers in concrete diminish the voids by enhancing packing density and addition of fibre reduce crack growth and development of new cracks.

Based on the compressive strength, the replacement of cement with alccofine was beneficial upto 10% and further, 12% or 14% replacement levels falls in strength were observed compared to mix with10% alccofine [18]. Replacement of cement with 10% alccofine and iron powder enhanced the maximum compressive strength of 43.52 N/mm^2, flexural strength of 5.1N/mm^2 respectively compared to the conventional concrete [19]. By the addition of polypropylene fibre range from 0.1% to 0.3% increases the cube strength3.77MPa to 28.22 MPa. The increases may be due to strong bonding between the PP fibre and matrix [20]. Beyond 0.3% compressive strength decreases due to the difficulty in dispersing the fibres in the concrete. 10%Zeolite, 1% nano silica and 1.0% fibres showed a maximum increase of 19.01% compressive strength when compared to control specimens [21]. The inclusion of PP fibres in specimens 0.5%, 1% and 1.5% showed an increase of 6.22%, 9.66% and 9.17% when compared to reference specimen [22].

The results shows that slightly increase in compressive strength by the addition of 15% alccofine, 10% zeolite, polypropylene fibresin the range of 0.1%-0.2%. Further addition of pp fibre strength has been noticeably decreased. Similar effects was also observed in previous works. Addition of 10% RHA increase in compressive strength and reduction in strength futher increase in RHA content [23]. Fibres can make a bridging effect between the cement paste and aggregate which leads to improvement in strength of concrete [24]. The increase in compressive strength may be attributed to the increase of bonding force between the components of concrete mix due to the presence of fibre. Increasing the percentage of fibre beyond 0.2% has caused the strength to decrease. The diminution may be due to the lump of non-contiguous fibres and this makes the strength of concrete matrix against the formation of cracks is very weak [17].

3.1.1 Failure Mode of cubes & cylinder

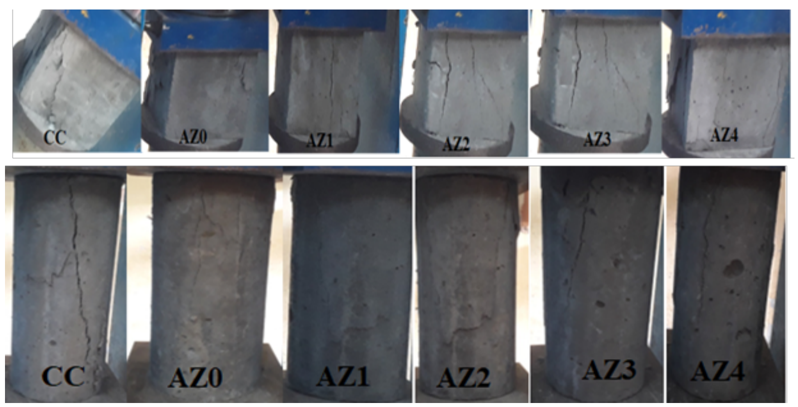

Fig 3. The failure pattern of cube specimens and cylinder specimens

For the specimens test under compression the same mode of failure was observed for the control specimens, ternary blended concrete specimens and fibre reinforced ternary blended concrete specimens. Macro cracks were observed over the surface of specimen without fibre and some amount of spalling also occur. Indicates of ternary blended concrete specimens, the extent of cracking and spalling was less compared to control. With the addition of fibres, the tendency of specimen to crack very much delayed as the results of the stitching action caused by the randomly oriented fibres. The spalling was very much minimized due to the inclusion of fibre reinforcement. By inclusion of nano silica and GGBS improves the bond between the concrete matrix [25]. Concrete with fibres increases the ductility of concrete and reduces the stress concentration [21]. Concrete cylinder made with CR and fibre do not exhibit brittle failure like control specimens. Fibre is effective in preventing cracking because it creates a strong bond between the aggregate and cement paste and holds the aggregates particle together to resist cracking [24].

Figure 3 shows the failure pattern of cube and cylinder specimens obtained through experimental observation. From the results, it is clearly observed that specimens made with polypropylene fibre exhibit bridging effects with microcracks, while macrocracks were observed at the surface of specimens made without polypropylene fibre.

3.2 Modulus of Rupture

The percentage increase in flexural strength is shown in Figure 4. The prism specimens AZ1 and AZ2 showed an increase of 2.33%, 3.49% when compared to the AZ0. The prism specimens AZ3 and AZ4 showed an increase of 5.47% and 10.47% when compared to the AZ0.

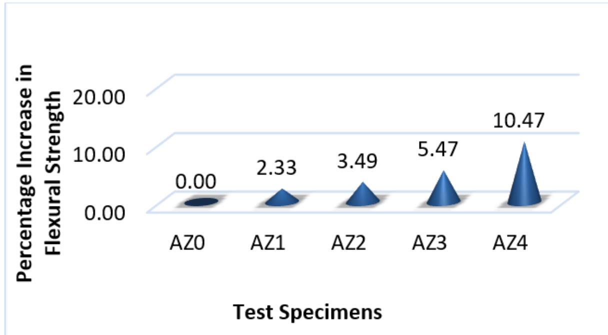

Fig 4. Effect of polypropylene fibre on flexural strength. The graph shows that specimens made with fibres were compared with specimens made without polypropylene fibres

By the incorporation of PP fibre, the flexural strength increases upto 0.6% for all the specimens [7]. The increases may be due to the effect of arbitrarily oriented PP fibres that produces the higher energy absorption. The increases in flexural strength to alccofine based mixes may be attributed due to strong bonding (ITZ) between the aggregates and cementitious materials [18]. The flexural strength of prism specimens made with and without polypropylene fibres are presented in Table 5. Each value represent average of the test result of three specimens. By increase fibre volume fraction from 0.5% to 2% the rate of increase in flexural strength 4.2MPa to 6.8MPa [25]. The flexural strength found to be increased 4.7MPa to 7.4MPa with an increase in fibre volume fraction 0.1% to 0.4% [20]. The higher flexural strength was obtained at 10% zeolite, 1% nano silica and 1.5% fibres. The maximum increase of 23.56% when compared to control specimens [21]. By the addition of fibres in the range of 0.5%-1.5% exhibited an increase in flexural strength of 9.22% to 25.33%. Similar effects was also observed in previous works. The specimens were not reinforced with pp fibres exhibited brittle failure, The PP fibres reinforced specimens however, exhibited ductile failure [23]. From the test results observed that PP fibres had been significantly contribute to reduce the width of the cracks. Confining or preventing crack propagation by PP fibre can significantly increase the service life of concrete [17].

Table 5. Mechanical Properties of Specimens

S.No	Mix ID	Al (%)	Z (%)	PPF (%)	Cube Compressive Strength (Mpa)	Cylinder Compressive Strength (Mpa)	Modulus of Rupture (MPa)	Modulus of Elasticity (GPa)
1	CC	0	0	0	32.95	26.56	6.5	29.78
2	AZ0	15	10	0	34.85	27.98	8.6	30.52
3	AZ1	15	10	0.1	35.69	28.85	8.8	31.87
4	AZ2	15	10	0.2	37.59	30.15	8.9	32.65
5	AZ3	15	10	0.3	40.13	32.14	9.07	33.67
6	AZ4	15	10	0.4	36.08	29.86	9.5	34.9

3.2.1 Failure Mode of Prisms

The failure pattern of all the prism specimens are presented through Figure 5. The prism specimens made with control concrete, ternary blended concrete and fibre reinforced ternary blended concrete failed in the same passion under four-point bending. A major crack was initiated at the mid span which progressed with increasing loading leading to the failure of the specimens. For prism specimens made with ternary blended concrete the formation of major cracks was delayed. The bridging action of micro reinforcement would have resulted in an increase in flexural load as fibre volume fraction increased [25]. With the inclusion of fibres the tendency of prism specimen was restrained due to the bridging action of the fibre reinforced. The introduction of the fibre reinforcement didn't allow the specimen to split into two pieces has happened with specimens made of control concrete and ternary blended concrete. By the addition of PP fibre restricts the crack growth [20]. The crack width decreased with increasing fibre volume fraction [10,21]. Similar effects was also observed in previous works. Specimens made with pp fibres initial cracks started in the cement matrix, but they did not propagate as fast in the case of plain mortar specimens. This is due to the reinforcing ability of PP fibres to limit cracking from its unique high strength bond with the cementitious materials [23]. The authors also reported that increasing the fibre content to 0.3% when cracks occurred and propagated, the fibres were able to bridge across the cracks, preventing the cracks-face separations. The fibres sustained the load until they pulled out from the matrix. From the failure pattern in Figure 5 observed that enough PP fibres is distributed in the matrix to bridge any growing micro cracks, the additional energy is consumed in breaking or pulling out the fibres, hence leading to higher failure load and toughness to the materials. The flexural strength increases due to increasing of fibre inclusion in the concrete mixture. This occurs because fibres creates a good bridge between the aggregate and cement matrix [24]. The specimens with polypropylene fibres had a minimum width of cracks due to stitching action, whereas maximum crack width and sudden failure were observed for specimens made without polypropylene fibres.

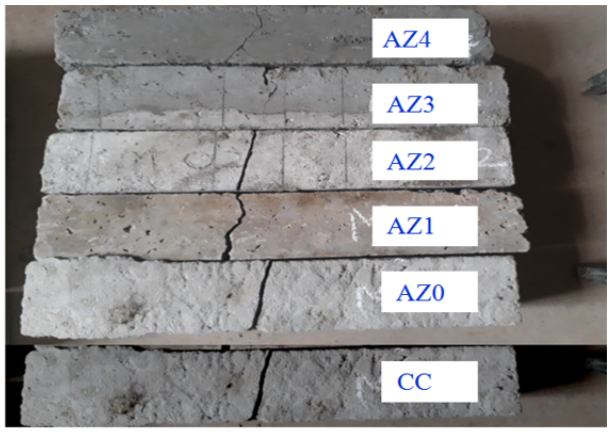

Fig 5. Failure pattern of prism specimens obtained through experimental observation

3.3 Modulus of Elasticity

The elasticity modulus of cylinder specimens with and without polypropylene fibres are presented in Table 5. Each value represent average of the test results of 3 specimens. Figs shows the details the rate of strength increment in % for elasticity modulus. The specimens AZ1 and AZ2 showed an increase of 4.90% , 6.98% when compared to the AZ0. The specimens AZ3 and AZ4 showed an increase of 10.32% and 14.35% when compared to the AZ0.The modulus of elasticity was found to increase with increasing fibre content the effect of polypropylene fibres on elasticity Modulus is shown in Figure 6. The addition of PP fibres modulus of elasticity 0.86% to 11.86% found to be increased with increasing PP fibre in the range of 0.1% to 0.4% [20]. The inclusion of fibres in the range of 0.5% to 1.5% was found to be 7.92% to 13.71% increases the modulus of elasticity [21].

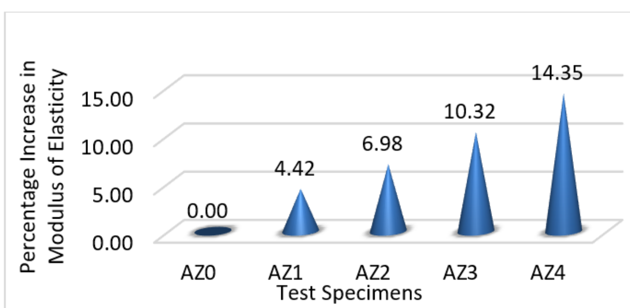

Fig 6. Effect of polypropylene fibre on modulus of elasticity. The graph represents the comparison made between specimens made with and without polypropylene fibres

3.3.1 Failure Mode of cylinder

The cylinder specimen were tested in a CTM and subjected to axial loading. A macro crack was observed over the height of the concrete cylinder made without polypropylene fibres. Multiple micro cracks were observed over the height of the concrete cylinders made with polypropylene fibres. The specimen's failure pattern is shown in Figure 7. The specimen without PP fibre major cracks were observes whereas the specimen with PP fibre enhancing the confinement mechanism (20). Specimen with fibres attain a high modulus of elasticity which enhances the capacity to deform before cracking and also resist crack formation (21). The inclusion of fibres, the failure pattern of specimen changed and increase crack density due to interlocking mechanism of fibre.

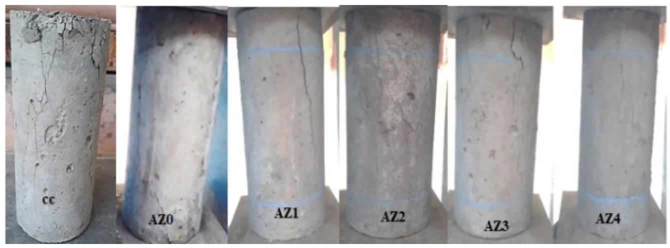

Fig 7. Failure pattern of cylinder specimens obtained through experimental observation. Cylinders made with polypropylene fibre having longitudinal microcracks were observed, whereas in specimens without fibres, macrocracks and the spalling effect of concrete were observed

3.4 Water Absorption

Specimen AZ0, AZ1, AZ2, AZ3 and AZ4 showed a decrease of 0.34%, 0.29%, 0.25%,0.18% and 0.13% in water absorption when compared to control concrete. The effect of fibres on water absorption is shown in Figure 8. The results of the tests of water absorption of all the specimens are presented in Table 6. The results of the tests indicated that as the fibre volume percentage increased, water absorption decreased. By the addition of fibre 0.1%, 0.2% and 0.3% resulted in decrease in water absorption. The decrease may be due to uniform dispersion of fibres, whereas beyond 0.3% increases the water absorption. The increases may be due to agglomeration of fibres (26). Similar effects was observed in previous works. The decrease and then increase in depth of water penetration may be due to increase in porosity with increasing in fibre content. The decrease in depth of water is probably due to pore blocking effect and less capillary porosity (27).

Table 6. Water Absorption

Test Specimen	Initial Weight	Final Weight	Percentage of Water Absorption
CC	8.542	8.574	0.37
AZ0	8.568	8.597	0.34
AZ1	8.277	8.301	0.29
AZ2	8.46	8.481	0.25
AZ3	8.522	8.537	0.18
AZ4	8.471	8.482	0.13

3.5 Porosity

The test result of porosity of all the specimens are presented in Table 7. The test result indicated a decrease in volume of permeable voids with an increasing fibre volume fraction in the concrete. Figure 9 shows the details percentage of water absorption for all specimens. This is may be attributed to good bonding between the PP fibres, aggregates, and cement matrix. The inclusion of polypropylene fibres in concrete enhanced the pore blocking effect. The effect of fibres on porosity is shown in Figure 9. Specimen AZ0, AZ1, AZ2, AZ3 and AZ4 showed a decrease of 0.98%, 0.89%, 0.86%, 0.80% and 0.71% when compared to CC.

The voids gets reduced with the inclusion of fibre at range from 0.3%, beyond this stage voids gets increased. The decreases may be due to stiching action of fibre and increases may be dur to fibres collation (26).

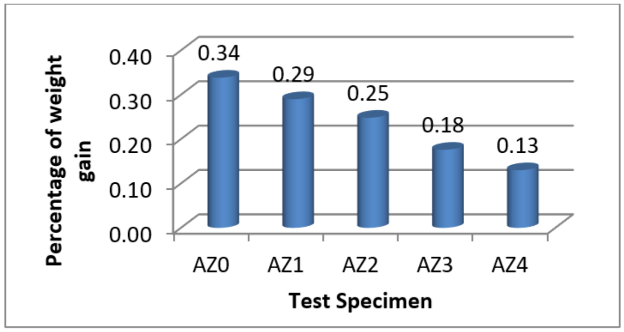

Fig 8. Effect of polypropylene fibre on water absorption. From the experimental observation, specimens made with polypropylene fibre required less water for observation compared to specimens without fibre

Table 7. Porosity

Test Specimen	Initial Wt	Wt after immersion in water	Wt 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	0.89
AZ2	8460	8481	8489	2.53	0.86
AZ3	8522	8537	8549	2.53	0.80
AZ4	8471	8482	8495	2.53	0.71

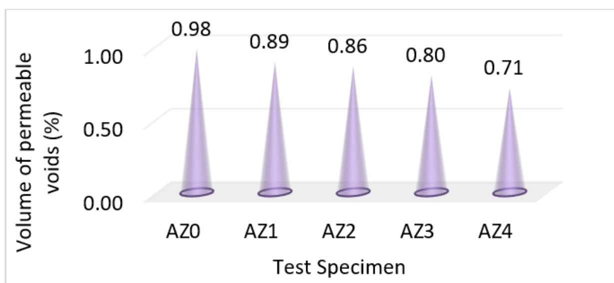

Fig 9. Effect of polypropylene fibre on porosity. According to the experimental observation, porosity was minimised in specimens made with polypropylene fibre. The diminution due to the inclusion of fillers and fibres

3.6 Sorpitivity

Sorptivity is the capacity to absorb water through capillary rise in the hardened concrete. The effect of fibres on sorpitivity is shown in Figure 10.

The sorptivity depends on the porosity of the concrete. The polypropylene fibre acts filling the pores and reduces the absorption. Concrete with 0.3% volume fraction of PP fibres and 15% alccofine with 10% zeolite shows reduced sorptivity result than other concretes mixes. The sorptivity coefficient is reduced for fibre concrete when compared to the control concrete. This may be attributed to impact of fibres filling pores, which leads to lack of inner connectivity of pores. The sorptivity graph is shown in Figure 10. By the inclusion of fibres at range of 0.1% to 0.3% sorptivity gets reduced. But, 0.4% it get increased due to bundling of fibres [(26)]. Similar results was observed in previous works. The sorptivity coefficient for all PP fibres specimens are lower than that of control concrete. This results shows significant reduction in capillary porosity and inner connectivity of pores by using pp fibres [(27)].

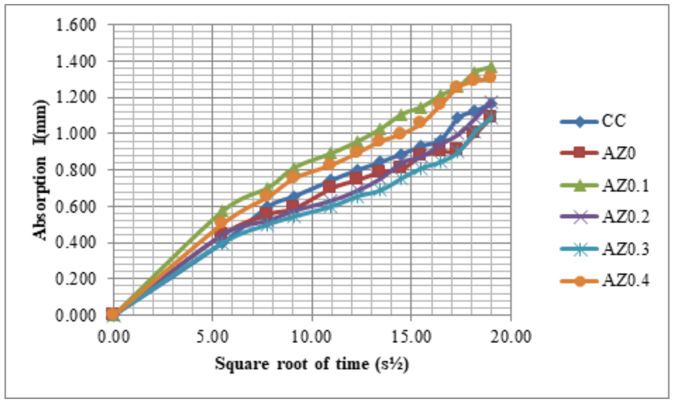

Fig 10. Sorptivity graph for all the species. Graphs were drawn between the square root of time on the X-axis and absorption on the Y-axis

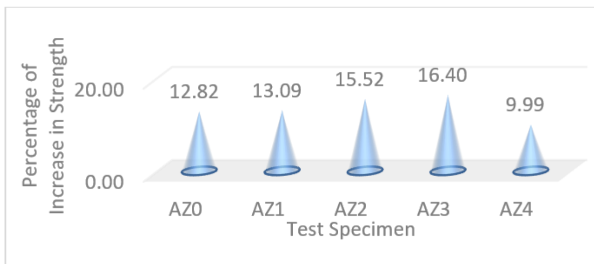

Fig 11. Effect of fibre on acid resistance (strength loss).The graph represents the comparison between strength obtained before acid immersion and strength attained after acid immersion

3.7 Acid Resistance

The specimens AZ1, AZ2, AZ3 and AZ4 showed a increase of 12.82%, 13.09%, 15.52%, 16.39%, 9.98% when compared to the CC. The percentage of strength loss is shown through Figure 11. The comparison of compressive strength is shown in Figure 13. The failure pattern of cube specimen is shown in Figure 14. The test result showed that as the proportion of volume fraction of PP fibres in the concrete increased, the specimen's strength increased. This indicates polypropylene fibres highly resistance to acid attack when compared to specimen without PP fibres. The percentage of weight loss is shown through Figure 12 . The specimens AZ1, AZ2, AZ3 and AZ4 showed a decrease of 0.34%, 0.29%, 0.25% , 0.18% and 0.13% in weight loss when compared to the CC. The test results indicated that polypropylene fibres creates an interfacial transition zone stronger and reduces the spalling effect of concrete. By the addition of 0.1%, 0.2%, 0.3% fibre resulted in reduction in decreasing trend of loss in mass and strength [26].

4 Conclusion

These research studies expressed the usage of industrial byproduct as mineral admixture for replacement of cement in concrete. The use of mineral admixture increases the mechanical and durability properties of concrete. Although, the mineral admixture is expensive when compared to pozzolanic materials. But, the usage of mineral admixture in concrete to make environmental ecofriendly by absorbing CO_2 gas in the atmosphere. Therefore, the production of green concrete which achieved positive impact on environment and other ways to reduce the damping of industrial byproduct and make reuse as a construction materials.

The focus of this study is on the influence of polypropylene fibre. Drawn the following conclusion based on experimental results,

1. Introduction of polypropylene fibres caused a significant positive impact on the various mechanical characteristics of alccofine and zeolite-based concrete.

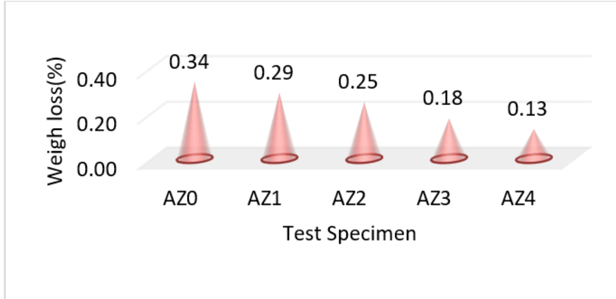

Fig 12. Effect of fibre on acid resistance (mass loss). The graph represents the comparison between the weight of the sample before and after acid immersion

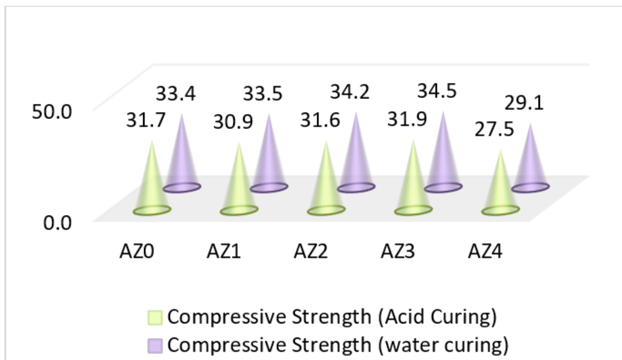

Fig 13. Effect of fibre curing on compressive strength (water curing and acid curing). The graph represents the strength achieved by each specimen as obtained through experimental observation

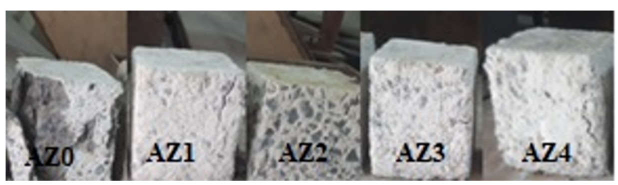

Fig 14. Experimental observation offailure pattern of cube compressive strength under acid curing. From the testresults, observed that spalling effect, strength loss and mass loss were morein specimens made without polypropylene fibres

2. A maximum increase of 15.15% in cube compressive strength, 14.87% in cylinder compressive strength has been obtained by the addition of 0.3% volume fraction of polypropylene fibres.
3. A maximum increase of 10.47% in flexure strength and 14.35% in modulus of elasticity has been obtained by the inclusion of 0.4% volume fraction of polypropylene fibres.
4. Considerable improvement has been experienced in durability properties of ternary blended concrete containing Alccofine and Zeolite in terms of reduction in water absorption (0.13**%),** Porosity (0.71**%)** and Sorpitvity.
5. Resistance to acid attack has also improved appreciably (16.39%)

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