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Strength and Durability Study on Polypropylene Fibre Reinforced Ternary Blended Concrete Containing Alccofine and Zeolite.

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Abstract

The study was an experimental evaluation of the strength of concrete incorporating Alccofine, Zeolite, and Polypropylene fibres. Zeolite (10%) and Alcofine (15%) have been used in place of cement in this study. Trials have been conducted to determine the optimum combination. As a fine aggregate, a mixture of natural river sand (55%) and M-Sand (45%) was used. For all the mixtures, the water to binder ratio was kept constant at 0.5. Volume fractions of 0.1%, 0.2%, 0.3%, and 0.4% of polypropylene fibres were added. Through a typical testing approach, the mechanical and durability characteristics of concrete, such as compressive strength and water absorption, were determined for concrete mixes with and without PP fibres.According to the test results, adding polypropylene fibre to a cube and cylinder increased their compressive strength to a maximum of 15.15% and 14.87 % respectively, and decreased water absorption to 0.13%.

1. INTRODUCTION

In present days, cement is being used on large scale in the production of concrete for building activities. Due to which the consumption of raw materials is high which cause the large amount of carbon dioxide (CO_2) release in the atmosphere. In order to rectifying this made usage of industrial byproduct as pozzolanic materials. The utilization of byproducts minimize the cement consumption at same time prevent industrial byproduct dumped into the landfill. Addition of Alccofine as 10%

partial replacement of cement and fine aggregate as iron powder increase the compressive strength and flexural strength (B.Venkatesan et al 2020).Alccofine increase the self compatibility characteristics like filling ability, passing ability and resistance to segregation (M.Vijaya Sekhar Reddy et al 2016). CaO present in Alccofine when combine with water under mix provides high resistance against chemical and acid attacks (P.R.Kalyana Chakravarthy and R.Rathan Raj 2017). The combination of fly ash and Alccofine as a replacement of cement which leads to eco friendly and sustainable concrete (Bode Venkata Kavyateja et al 2020). The replacement of cement with Alccofine showed improvement in flexural and compressive strength along with increased workability and fluidity (Raghul Raj Kundanati et al 2020). The adding of both crumb rubber and zeolite to concrete decrease the density of the concrete (Farnoosh Jokar et al (2019). Concrete contained 15% natural zeolite reached a suitable compressive strength, water penetration, chloride ion penetration, corrosion rate, drying shrinkage and it also did not demand too much super plasticizer (Meysam Najimi et al 2012). Polypropylene fibers are highly effective in controlling plastic shrinkage cracking in concrete (Nemkumar Banthia, Rishi Gupta 2006). Addition of polypropylene fibers decrease the workability of the concrete composite containing fly ash and silica fume (Peng Zhang, Qing fu Li 2013).

2.EXPERIMENTAL PROGRAMME

To check the performance of Polypropylene Fiber Reinforced Concrete containing with Alccofine and Zeolite have been studied in this investigation.

MATERIALS USED

2.1. CEMENT

Following IS: 12269-2013, Ordinary Portland Cement of Grade 53 was used. Table 1 shows the properties of thecement used.

Table 1. Properties of Ordinary Portland Cement

S.No	Aspects	Test value	As per IS:12269-2013
1.	Cement Consistency	33%	-

2.	Specific Gravity	3.140	3.150
3.	Initial Setting Time	32minutes	>30 minutes
4.	Final Setting Time	250minutes	<600 minutes

2.2.FINE AGGREGATE

A combination of Natural River sand (55%) and Manufactured Sand (45%) has used in this study and conforming to grading zone III of IS 383:2016. The properties of fine aggregate presented in Table.2.

Table.3 Sieve Analysis of Fine Aggregate

Sieve Size	Weight Retained (g)	Percentage Passing	As per IS:383-2016 (Zone III)
4.75mm	0	100	90 – 100
2.3mm	5	99.5	95-100
1.18mm	214	78.1	55-90
600µ	200	58.1	35-59
300µ	458	12.3	8-30
150µ	75	4.8	0-10

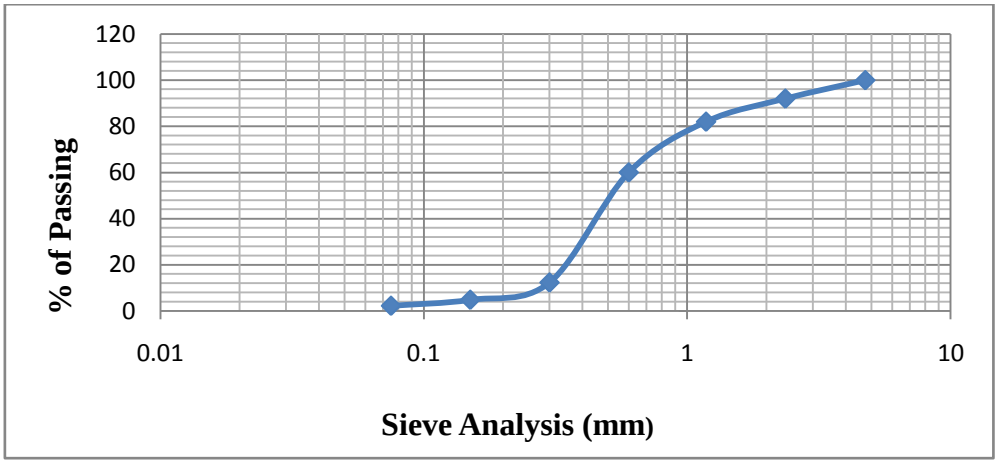

Fig.1 Grain Size Distribution Curve

2.3.COARSE AGGREGATE

Natural crushed angular 20mm and 10mm size of aggregate have used as per conforming IS 383:2016. The specific gravity of course aggregate is 2.72.

2.4. ALCCOFINE 1203

Alccofine 1203 have low calcium silicate with ultra fine particles distribution. Due to its ultra finess of Alccofine 1203 it reduced water demand for given workability of concrete. Alccofine 1203 was sourced from Astra Chemicals, Chennai. Table.3 represents the properties of Alccofine.

Table.3 Properties of Alccofine 1203

S.No	Description	Unit	Range
1.	Fineness	m^2/kg	120
2.	Specific Gravity	-	2.73
3.	Bulk density	Kg/m^3	878

2.5. ZEOLITE POWDER

Zeolite available in powdery form for the partly replacement of cement in concrete.It has the good pozzolanic reactivity and ability to absorb green house gas emitting from the atmosphere. The zeolite have silica content is 80.5%, alumina is 4.2%, iron oxide is 2.2%, magnesia is 1.5% and lime is 4.3%. Table.4 shows the properties of Zoelite.

Table.8 Properties of Zeolite

S.No	Description	Range
1.	Color	White
2.	Specific gravity	2.98
3.	Fineness	8

2.6. POLYPROPYLENE FIBER

Polypropylene fiber in concrete mix design is used for multi purpose that include rigid pavement, self compacting concrete and other applications. The addition of polypropylene fiber improved the

mechanical properties such as flexure strength, compressive strength and tensile strength in concrete. It can be effective in providing strain and crack opening resistance only within a limited range. Table.5 shows the properties of polypropylene fiber.

Table.5 Properties of Polypropylene Fiber

S.NO	Description	Range
1.	Type of fiber	Polypropylene
2.	Aspect Ratio(L/D)	300
3.	Tensile strength(Mpa)	450

2.7. WATER

Water available in our university campus was used for the purpose of casting and curing of the specimens as per code IS 456:2000

2.8. SUPER PLASTICIZER

Conplast SP430 is a chloride free, super plasticizing admixture based on selected sulphonated naphthalene polymers. It is supplied as a brown solution which instantly disperses in water. Conplast SP430 disperses the fine particles in the concrete mix, enabling the water content of the concrete to perform more effectively. Table.6 shows the properties of sp conplast 430.

Table.6 Properties of SP Conplast 430

Sno	DESCRIPTION	RANGE
1.	Appearance	Brown Liquid
2.	Specific Gravity	1.18@25ºc
3.	Chloride Content	Nil
4.	Air Entrainment	<2%

3. MixProportion

As per IS10262-2019 the concrete mix design prepared for M25 grade concrete. The water cement ratio is taken as 0.50 from IS10262-2019 for maintain workability. Table.7 represents the Mix Ratio for M25 grade concrete. Five numbers of mixes were prepared with different combinations of Alccofine and Zeolite. Casting and testing of cubes(150mmx150mmx150mm) with constant quantity of Zeolite(ie,10%) and different dosage of Alccofine(10,15,20 and 25%)respectively. Testing of specimens after 28 days curing under compression testing machine.The test results indicated that the strength will be decrease at certain point due to increase the percentage of Alccofine and to fix optimum dosage of alccofine as 15% with the reference of compressive strength which obtained through the testing of cubes.Table.8 shows the finding of optimum percentage of Alccofine and Fig.2 represent the Slump values in mm.

Table.7 shows the Mix ratio for M25 grade concrete

Materials	**Cement**	**Fine Aggregate**	**Coarse Aggregate**	**Water Content**
Quantity (kg/m^3)	350	687	1245	175
Ratio	1	1.96	3.56	0.5

Table.8 shows to find the optimum percentage of Alccofine.

Mix	**Cement (kg/m^3)**	**Fine Aggregate (kg/m^3)**		**Course Aggregate (kg/m^3)**		**Alccofine (kg/m^3)**	**Zeolite (kg/m^3)**	**Slump in (mm)**	**Compressive strength at 28 days (N/mm^2)**
		River Sand	M-Sand	10mm	20mm				
CC	350	377.5	309.15	498	747	0	0	60	32.35
AZ1	280	377.5	309.15	498	747	35	35	55	33.49
AZ2	**262.5**	**377.5**	**309.15**	**498**	**747**	**52.5**	**35**	**54**	**34.95**
AZ3	245	377.5	309.15	498	747	70	35	53	32.04
AZ4	227.5	377.5	309.15	498	747	87.5	35	56	30.06

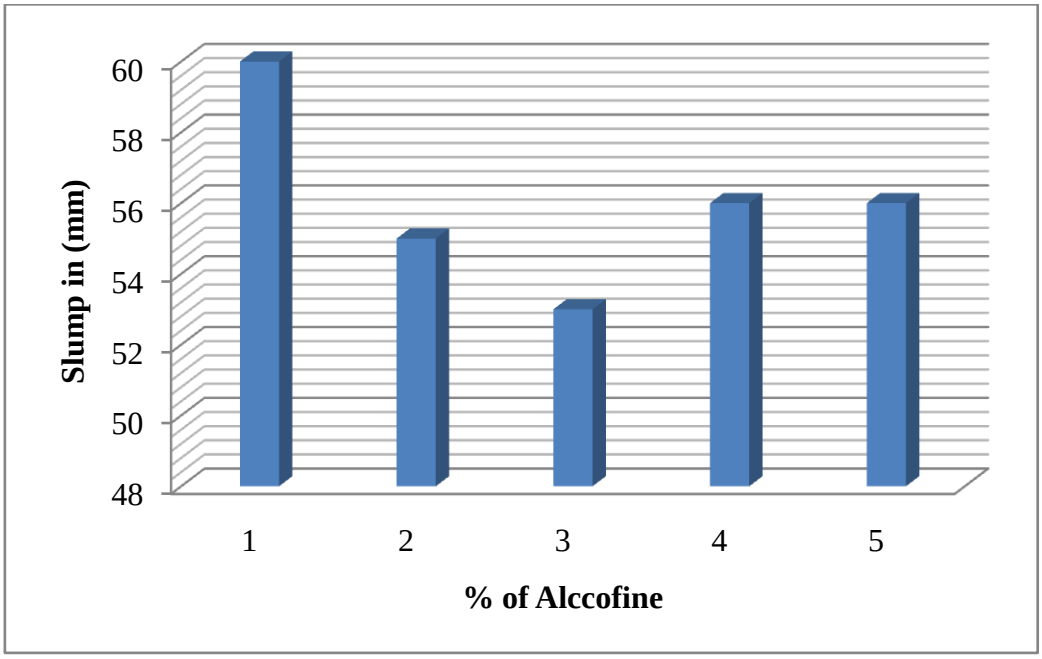

Fig.2 Graphical representation of Slump values in mm

4. Test Specimen and Methods

The mix AZ2 have shown the maximum strength. Hence it were concluded that the optimum percentage of replacement of cement by Alccofine could be taken as 15% with the reference of test results are tabulated in Table.8. After finding the optimum % of Alccofine and Zeolite five numbers of mix were prepared with different volume fractions of Polypropylene Fiber such as (0%,0.1%,0.2%,0.3% and 0.4%). Finally to casting the test specimens of different dosage of Polypropylene Fiber concrete with optimum percentage of Alccofine and Zeolite and cured the specimens until it testing. Cube and cylinder specimens(3 for each mix) were tested according to IS 516:1959 in a Compression Testing Machine of 200-ton capacity. The test set-up for determining the compressive strength of specimens is shown through fig.4.Cylinder specimens(3 for each mix) were cast and tested as per IS 516:1959 in a standard testing machine of 200-ton capacity Test specimens consist of cube (150mmx150mmx150mm). Casting and Testing of specimens after 28 days to obtain the mechanical properties and durability properties such as Compressive Strength and water absorption respectively. Cube specimens of size 150mmx150mmx150mm were cast and tested as per ASTM C642-97 . The test set-upfor water absorption is shown through Fig-4.

Fig.3 Test Setup for Compression Strength Test (Cubes & Cylinders)

Fig.4 Test Set –up for Water Absorption

5.Results and Discussion

5.1 Compressive Strength Test

Compare the compressive strength of conventional concrete (CC) and concrete containing optimum dosage of Alccofine and Zeolite with different volume fractions of Polypropylene Fiber (0%,0.1%,0.2%,0.3% and 0.4%). It is clearly observed that the Polypropylene Fiber concrete with Alccofine and Zeolite showed higher compressive strength than Conventional Concrete. The compressive strength of mixes AZ0,AZ1,AZ2,AZ3 and AZ4 was improved by 8.82%, 9.35%, 11.81%, 13.45%, 3.03% respectively in compared to conventional concrete. It was also noticed that

the compressive strength were increased when cement content replaced up to optimumof 15% Alccofine and 10% Zeolite. Therefore it can be concluded that the decrease in strength on addition on Alccofine beyond 15% because the Alccofine much finer than cement and increase the water demand for workable mix which may leads to effects pore structure of concrete. Table.9 Shows the results of compressive strength test for cubesand Cylinders. Fig.3 shows the pictorial representation of compressive strength at 28 days.

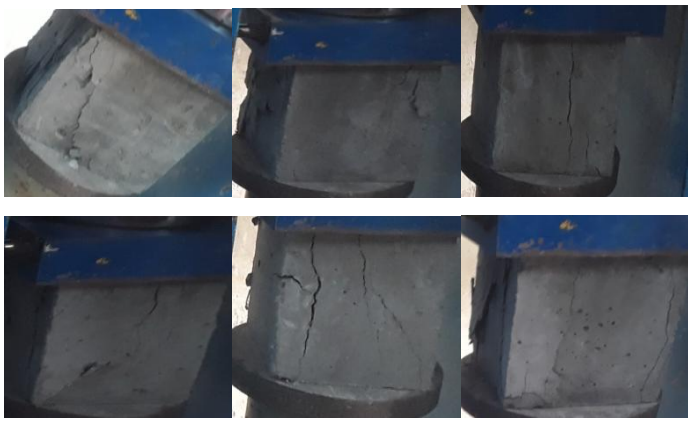

Fig.5 Failure modes of Cube Specimens

Fig.6 Failure modes of Cylinder Specimens

Table.9 Results of Compressive Strength Test for Cubes and Cylinder

S.No	Mix ID	**Al(%)**	**Z(%)**	**PPF(%)**	**compressive strength at 28 days (N/mm²)(CUBE)**	**compressive strength at28 days (N/mm²)(CYLINDER)**
1.	CC	0	0	0	30.04	29.7

2.	AZ0	15	10	0	32.69	32.14
3.	AZ1	15	10	0.1	32.85	33.09
4.	AZ2	15	10	0.2	33.59	34.64
5.	AZ3	15	10	0.3	34.08	35.54
6.	AZ4	15	10	0.4	29.13	30.01

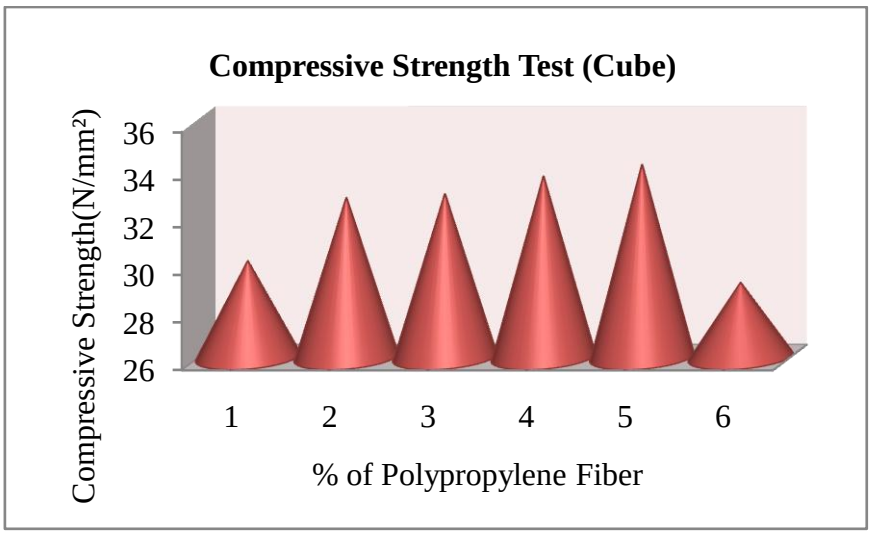

Fig.7 Pictorial representation of Compressive strength at 28 days(Cubes)

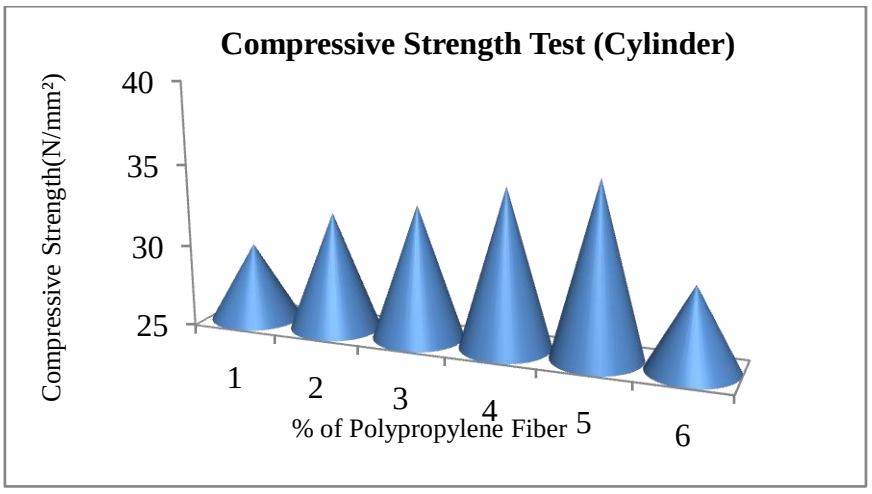

Fig.8 Pictorial representation of Compressive strength at 28 days(Cylinder)

5.2 Water Absorption

The test results of water absorption of all the specimens are presented in Table 13. The effect of fibres on water absorption is shown in **Fig.20.** Specimen AZ0, AZ,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 test results indicated a decrease in water absorption with an increasing fibre volume fraction.

Table 10 Water Absorption

Test Specimen	Initial Weight	Final Weight	% 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	0.30

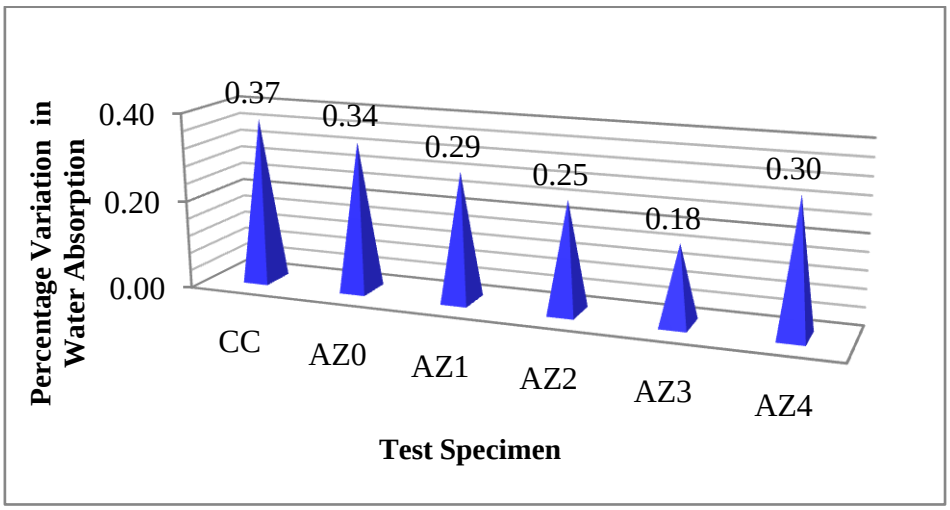

Fig.9 Effect of Fibres on Water Absorption

4 Conclusions

The focus of this study is on the influence of polypropylene fibre.

1. Incorporation of polypropylene fibres caused a significant positive impact on the various mechanical and durability characteristics of alccofine and zeolite-based concrete.
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. Considerable improvement has been experienced in durability characteristics of ternary blended concrete containing Alccofine and Zeolite with 0.3% volume fraction of polypropylene fibrein terms of reduction in water absorption (**0.13%).**

Authors contribution

All the authors contributed to the formulation of the problems and material selection, design of experiments, testing methodology, selection of analysis tools, and preparation of manuscript. All the authors read and approved the final manuscript.

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