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Experimental Study on Various Mineral Admixtures in Fibre Reinforced Concrete

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ABSTRACT

The quantity of fly ash produced from thermal power plants in India is approximately 80 million tons each year, and its percentage utilization is less than 10%. An attempt has been made to utilize these cheaper materials in concrete production. This thesis aims at investigating the characteristics of fresh concrete and various strengths of hardened concrete made with various mineral admixtures such as fly ash. GGBFS, silica fume. Rice husk ash along with polypropylene fibres in various proportions. M20 grade concrete is considered for experimental studies with 53grade Ordinary Portland Cement blended with varying percentages of mineral admixtures. The maximum size of coarse aggregate used is 20mm. Various mineral admixtures such as fly ash. GGBFS.Silica fume. Rice Husk Ash were added concrete in various percentages by partially replacing cement and the optimum percentage of the mineral admixtures will be found. Based on the obtained values, the admixture with maximum mechanical strength is determined and to this polypropylene fibre is added by varying 0 to 0.5 % by weight of cement to the mix. The test results obtained were compared and discussed with conventional concrete.

Keywords: Fly ash, Ground granulated blast furnace slag, Silica fume, Ricehush ash, Polypropylene fibre, Mineral admixtures, Conventional concrete.

1. INTRODUCTION

Concrete is the most widely used man-made construction material in the world. It is obtained by mixing cementations materials, water, aggregate and sometimes admixtures in required proportions. Since the cost of cement have increased due to increased cost of production or increased demand, there is an urgent need to replace them partially or wholly by cheaper materials. The popularity of concrete is due to the abundance of raw material, excellence in strength and durability, low manufacturing and maintenance costs, versatility in forming various shapes and its unlimited structural applications in combination with steel reinforcement. However, the concrete industry faces a big challenge due to its vital component cement. The production of cement is an energy intensive process, and the emission of carbon dioxide during the cement production raises environmental concerns and there are increasing incidents where cement leads to distress in concrete in hostile environmental conditions. These factors have led to the thought of reduction of cement consumption and to intensification of research in exploring the possibility of enhancing strength and durability through the use of mineral admixtures. This leads to the increasing use of cementations materials that can serve as partial substitutes for Portland cement, in particular those materials that are by-products of industrial processes such as fly ash, ground granulated blast-furnace slag, silica fume, rice husk ash etc., In plain concrete, structural cracks develop even before loading, particularly due to drying shrinkage or other causes of volume change. The width of these initial cracks seldom a few microns, but their other two dimensions may be of higher magnitude. Also this becomes a major cause for the reduction in the compressive strength of the concrete. In order to arrest cracks and to improve the properties of concrete, small, closely spaced and uniformly dispersed fibres can be added along with concrete. This type of concrete is called fibre reinforced concrete. Numerous applications of fibre reinforced concrete are found in the concrete construction industry. In this project an attempt has been made to analyze the effects of pozzolanas in fibre reinforced concrete.

2. MATERIALS AND METHODOLOGY

2.1. Cement

For this research work Ordinary Portland Cement (OPC) 53 grade conforming to IS 8112 – 1989 was used.

2.2 Coarse aggregates

Locally available coarse aggregates having the maximum size of 20mm were used in the present work. Testing of coarse aggregates was done as per IS: 383-1970. The 20mm aggregates were firstly sieved through 20mm sieve. They were then washed to remove dust and dirt and were dried to surface dry condition.

2.3 Fine aggregates

The sand used for the experimental programmed was locally procured and conformed to grading zone III as per IS : 383-1970 The sand was first sieved through 4.75 mm sieve to remove any particles greater than 4.75 mm and then was washed to remove the dust

2.4 Fly ash

Fly ash is the most widely used supplementary cementations material in concrete. It is a by-product of the combustion of pulverized coal in electric power generating plants. Fly ash is a finely divided powder resembling Portland cement. The fly ash is obtained from mettur thermal power plant, tamilnadu, India

Table1. Properties of fly ash

Specification	Limits
Silica (SiO2)	47.0-55.0
Aluminium (Al2O3)	25-35
Calcium (CaO)	4.0-10.0
Magnesium (MgO)	1.0-2.5
Sulphur (SO3)	0.1-0.5
Loss On Ignition (LOI)	0.5-2.0

Specific Surface Area(cm2/g)	8500
Specific gravity	2.6

2.5Ground Granulated Blast furnace slag

(GGBFS) is a by-product for manufacture of pig iron and obtained through rapid cooling by water or quenching molten slag.

Table 2. Properties of ggbfs

specification	limits
Form/colour	Powder/white
Specific Gravity	2.7-2.90
Bulk density	1200-1300kg/m3

2.6 Rice husk ash

Rice husk ash is obtained by burning rice husk in a controlled manner without causing environmental pollution

Table 3. Properties of ricehusk ash

Specification	Limits
Form/colour	Powder/black
Specific gravity	2.04
Bulk density	0.721 g/cc

2.7 Silica fume

Silica fume also referred as micro silica or condensed silica fume is another material that is used as an artificial pozzolanic admixture.

Table 4 Properties of silica fume

Specification	Limits
Form/colour	Powder/white/grey
SiO_2	90%
H_2O(moisture), max	3.0%
Bulk density	600kg/m^3

2.8 Polypropylene fibres

Recron3sfibres were used to prevent the shrinkage cracks, also it helps to increase flexural strength. RECRON 3s fibres are environmental friendly and non hazardous.

Table 5. Properties of polypropylenefibre

Material	Recron Fibre
Specific gravity	0.91

Typical dosage	0.9 kg/m3
Available lengths	6mm,12mm,18mm
Tensile strength	660 MPa
Modulus of elasticity	4000 MPa
Electrical conductivity	Low
Water absorption	Negligible
Acid and alkali resistance	Excellent
Fibre count	Approximately.14million/0.45 kg

2.9Water

Potable water was used to cast the concrete specimens. The water was free from oils, acids and alkalis and had a water soluble chloride content of 140mg/litre which is very much less than the permissible limit. As per IS 456 -2000, the permissible limit for chloride is 500 mg/litre for reinforced concrete.

3. TESTING OF SPECIMENS

3.1mechanical Strength Tests

3.11. Compressive Strength

This test was performed on cubical specimens of 150mm size. Cubes were cast using steel moulds, remolded after 24hours and cured by completely immersing in water. 9 numbers of cubes were cast for each concrete mix with partial replacement of cement by fly ash, GGBFS, RHA and silica fume in various proportions. 3cubes from each mix proportion of fly ash, GGBFS, RHA and silica fume were tested sequentially at a time on the 7th, 28th and 56th of casting and the average values obtained were compared with that of the control specimen

Table 6. Comparison of Compressive strength between control mix and optimum percentage of each mineral admixture

S.No	Mix	Compressive Strength N/Mm^2		
		7days	28 days	56 days
	CM (Control Mix)	16.35	26.58	35.32
	FA 20%	14.22	25.91	39.42
	GGBFS 20%	17.23	25.62	38.59
	RHA 15%	18.09	29.12	40.44
	SILICA FUME 15%	18.92	31.17	39.37

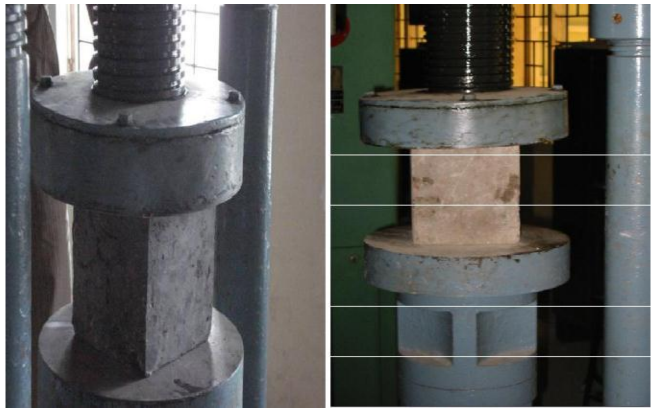
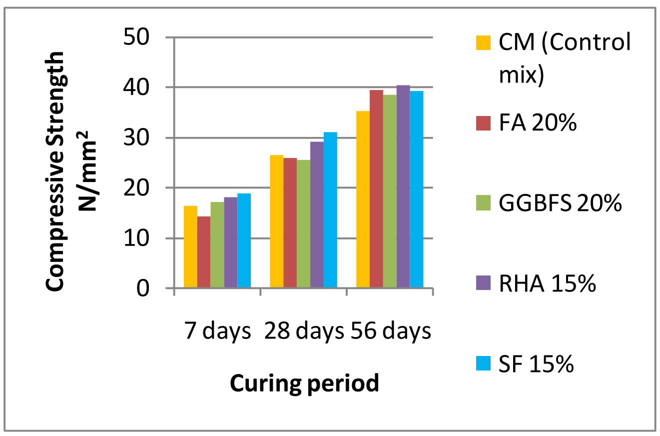


Fig 1 compression test setup

Though all mineral admixtures when added in various percentages improved the compressive strength of concrete after 56 days, of all the four mineral admixtures used in this experimental study, Rice Husk Ash (RHA) proved more efficient in enhancing the compressive strength. The optimum percentage replacement of cement with RHA (15%) is taken for further flexural and split tensile strength studies. Polypropylene fibres in 0%, 0.5%,1% , 1.5% and 2.0% by weight of cement is added to the RHA (15%) to form fibre reinforced concrete.

Fig 2 Compressive Strength of Concrete cubes in Various proportions



3.1.2.Split Tensile Strength Test

As there are no standardized methods to measure the tensile strength of concrete directly, an indirect method called cylinder splitting tension test was performed on cylindrical concrete specimens placed horizontally between the loading surfaces of a compression testing machine and the load was applied until failure of the cylinder along the vertical diameter.Cylinders of 150mm diameter and 300mm length were cast, cured and 3 numbers were tested sequentially at a time on the 7^{th}, 28^{th} and 56^{th} day of casting and the average values obtained were compared with that of the control specimen.

Fig 3. Split tensile strength test

Though the loading condition produces a high compressive stress immediately below the two generators to which the load was applied, a larger portion corresponding to depth will be subjected to a uniform tensile stress acting horizontally.

Table 7.split tensile strength of concrete specimens

S.No	Mix	Split Tensile Strength In N/Mm^2		
		7 days	28 days	56 days
1	CM(Control mix)	1.8	3.7	4.2
2	RHA15PP0	2.42	3.41	4.39
3	RHA15PP0.5	2.57	3.51	5.52
4	RHA15PP1	2.98	4.21	5.85
5	RHA15PP1.5	1.91	2.99	3.62
6	RHA15PP2	0.92	1.88	3.03

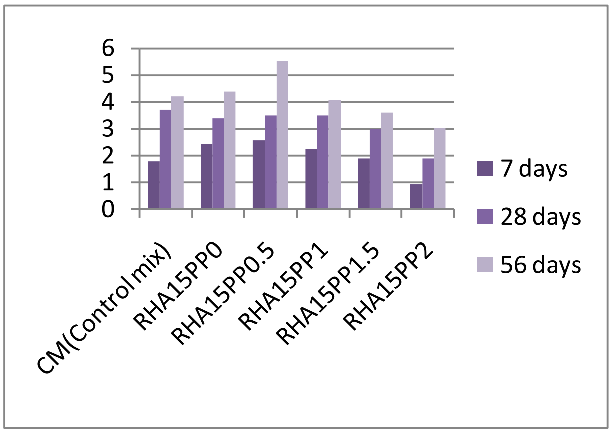


Fig 4. Split Tensile Strength of Concrete Specimens

3.1.3. Flexural Strength Test

Beam tests were cast and tested study the flexural strength property of concrete as per I.S. 516-1959. The value of the modulus of rupture (extreme fibre stress in bending) depends on the dimension of the beam and manner of loading. Since two point loading yield a lower value of the modulus of rupture than the centre point loading, the code specifies two point loading. Since the largest nominal size of the aggregate was only 20mm, beam specimens of size 100 x 100 x 500mm were cast, cured and 3 numbers of beams were tested

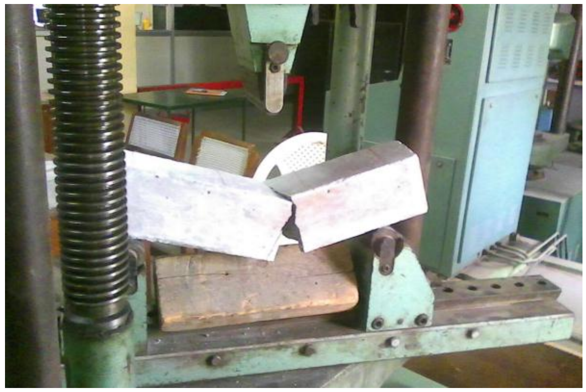


Fig 5.Flexural strength of concrete beams

Sequentially at a time on the 7^{th}, 28^{th} and 56^{th} day of casting and the average values obtained were compared with that of the control specimen.

Table 8. Flexural strength of concrete beams

S.No	Mix	Flexural Strength, N/Mm^2		
		7 days	28 days	56 days
1	CM(Control Mix)	3.20	5.60	6.20
2	RHA15PP0	3.31	5.40	6.90
3	RHA15PP0.5	3.38	5.60	6.80
4	RHA15PP1	3.42	5.80	7.20
5	RHA15PP1.5	3.20	4.60	6.50
6	RHA15PP2	3.20	4.40	6.52

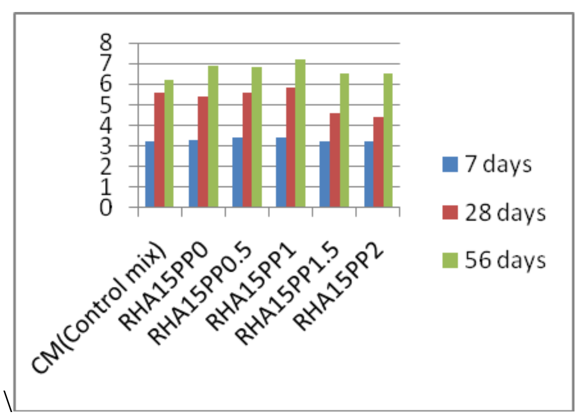


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Fig 6. Flexural strength of concrete beams

4. CONCLUSIONS

The following conclusions are derived based on the experimental study. The specimens cast with various percentages of mineral admixtures were subjected to various mechanical strength results and from the test results. It is determined that, In fresh state, as percentage of fly ash increases slump and compaction factor increase. Increase in percentage of fly ash RHA and Silica fume as partial replacement of cement in concrete increase the workability of concrete. The rate of increase in workability gradually decreased later on even though the incremental increase in GGBFS percentage was constant. 20% replacement of cement by fly ash has yielded the maximum compressive strength values with 22% increase in compressive strength. 20% replacement of cement by GGBFS has yielded the maximum compressive strength values with 24% increase in compressive strength. 15% replacement of cement by RHA has yielded the maximum compressive strength values with 33% increase in compressive strength. 15% replacement of cement by Silica fume has yielded the maximum compressive strength values with 31% increase in compressive strength. Though the 7 days strength test results of the RHA replaced concrete showed lower values at later age 56 days the strength of 15% RHA replaced concrete has shown 33% increase in compressive strength. Polypropylene fibres were added in various percentages 0.5%, 1%, 1.5% and 2% and it was determined that 1% of replacement by weight of cement in RHA 15% replaced concrete yielded the maximum mechanical strength values. Experimental test results have shown 31% increase in flexural strength and 17% increase in split tensile strength.

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Conflict of Interest

None of the authors have any conflicts of interest to declare.

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