

Experimental Study on the Influence of Fly Ash, Lime Powder and Hybrid Fibres on the Properties of Concrete

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ABSTRACT: This study is to characterize the optimum percentage of fly ash, Lime powder with hybrid fibres (steel and polypropylene). The above blending is to be tried, to meet the strength requirements in compression, split and flexural along with durability tests. The steel fibres are used to increase the strength of concrete. The addition of fly ash and lime powder by replacing the cement content. Specimens are cast with M₃₀ concrete. To save our earth resources to control the pollution from the manufacturing of cement (1 ton of cement releases 1 ton of CO₂) we have to utilize the easy available and waste materials like Fly ash & Lime powder. Polypropylene fibres and steel fibres are used to increase the flexural strength. Addition of the Supplementary Cementitious Materials (SCMs) not only reduces the permeability of concrete, but also increases the concrete strength. Steel fibres increases the compressive strength from 6% to 17%, tensile strength from 18% to 47%, flexural strength from 22% to 63%.

KEYWORDS: Fly Ash, Lime Powder, Hybrid Fibres, Compressive Strength, Split Tensile Strength, Flexural Strength.

I. INTRODUCTION

Recycling of large amount of waste materials such as fly ash, Lime powder (LP) etc is being done in large amount in the manufacture of cement. Addition of these Supplementary Cementitious Materials (SCMs) not only reduces the permeability of concrete, but also increases the strength of concrete by the formation of CHS gel by reacting with lime which is a by-product during cement reaction with water. This pozzolanic property of SCMs has been the reason for the enormous utilization of SCMs in cement. The replacement of cement by supplementary material not only results in savings of the materials, but also reduces the CO₂ emission in the atmosphere, since one ton of cement production results in one ton of CO₂ emitted in the atmosphere.

Use of admixtures in concrete has been practiced since 1900. In the early days, asbestos fibres was used in concrete. And in the 1950s the concept of composite materials came and the use of fibre reinforced concrete were introduced in large extend. By the 1960s, steel, glass (GFRC) and polypropylene fibres were used in concrete, and research into new fibre reinforced concrete continues today. Many of work have been done on replacement of cement with fly ash, which has shown good results with respect to strength and durability. Fly ash has given excellent results up to a replacement of 20% addition and have increased the performance of concrete with about 15% replacement in most of the research findings. Ternary blended pozzolanic material with LP contributes to hydration improving the early age and the long term compressive and flexural strengths also with durability which was verified by acid test and chloride ion penetration tests. The corrosion resistance of ternary blend mortar is higher than that of containing single pozzolano and the use of ternary blend OPC and FA is very effective in reducing chloride induced corrosion of mortar.

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II. LITERATURE REVIEW

Mini soman et al (2014) studied the strength and behaviour of high volume fly ash concrete. Fly ash generated by the burning of coal in coal fired power plants. This was considered as a material of very low value, useful only for land fill. Continuous research studies by various engineering research laboratories revealed its varied usefulness as an additive for enhancing the various qualities of concrete including its workability, strength and durability if handled and cared properly. The present study aims at developing a concrete by replacement of Ordinary Portland Cement (OPC) with 50% Fly Ash by mass. The fresh and hardened properties of High Volume Fly Ash Concrete (HVFAC) with 50% replacement of cement and Ordinary Portland Cement Concrete (OPCC) are studied. The study discloses that high volume of Fly Ash in concrete reduces the water demand and improves the workability. Study also reveals that the OPCC and HVFAC exhibit similar hardened properties. Comparison of flexural response of beams made with OPCC and HVFAC with different percentage of reinforcement are also studied. It was observed that HVFAC beams have shown notable improvement in the deflection, cracking behaviour and load carrying capacity. Partial replacement of cement with fly ash in concrete save much of the energy required for production of OPC and also facilitates the economical disposal of millions of tons of fly ash. Addition of fly ash improves the workability of concrete. Addition of 50% fly ash reduces 7 day strength by about 20% when compared to control mix. But it acquires strength almost equal to that of control mix at 28 days and attained higher strength thereafter and also cracking behaviour studies indicate that HVFAC beams are more crack free compared to OPCC beams.

Xuiping feng et al (2011) studied the Evaluation of the Physical and Chemical Properties of Fly Ash Products for Use in Portland cement Concrete. Fly ash is a by-product of the combustion of pulverized coal in electric powder generating plants. It was the most widely used supplementary cementitious material in concrete. The replacement level of class F fly ash was often replaced at 15-25% by mass of cementitious materials. The properties of fly ash can greatly affect the properties of both fresh concrete and hardened concrete. It was generally recognized that the addition of fly ash has been a beneficial effects on the rheological properties of cement paste and on the workability of fresh concrete. The small spherical particles of fly ash can reduce the water requirement. It was well known that class F fly ash has pozzolanic properties. It was also known that the most important factors affecting the pozzolanic reactivity of fly ashes are fineness and acidic oxide content. It was concluded that about 90% of fly ash tests can reduce the water requirement for mortar mixtures. About 80% of tested fly ash mixtures have gained in strength activity index from 7 days to 28 days.

III. MATERIAL DETAILS

1. Cement

Ordinary Portland cement or OPC conforming to *IS-12269-1987 (53 Grade)* was used for the experimental work. The cement used has been tested as per *IS 4031-1988* to determine specific gravity, fineness, standard consistency, initial setting time and is found to be conforming to various specifications of *IS 12269-1987*.

Table -1: Test Result of Cement

Sl. No	Property	Test Method	Test Results	IS Standard
1	Normal Consistency	Vicat Apparatus	30%	25-35%
2	Specific gravity	Sp. Gravity bottle	3.15	-
3	Initial setting time	Vicat Apparatus	30 minutes	Not less than 30 minutes
4	Fineness	Sieve test on sieve No.9	4%	<10%

2. Fine Aggregate (River Sand)

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Laboratory tests were conducted on fine aggregate to determine the different physical properties as per IS 2386 (Part III)-1963.

Table -2: Test Result of Fine Aggregate

<i>Sl. No</i>	<i>Particulars</i>	<i>Test Method</i>	<i>Value</i>
1	Specific Gravity	Pycnometer (IS:2386 Part 3 1986)	2.74
2	Fineness modulus	Sieve Analysis (IS:2386 Part 2-1963)	4.923

3. Coarse Aggregate

The aggregate of size 20 mm was considered as coarse aggregate. Laboratory tests were conducted on coarse aggregate to determine their properties as per IS: 2386 (Part III) – 1963.

Table -3: Test Result of Coarse Aggregate

<i>Sl. No</i>	<i>Particulars</i>	<i>Test Method</i>	<i>Values</i>
1	Specific Gravity	Pycnometer (IS:2386 Part 3-1986)	2.74
2	Fineness modulus	Sieve Analysis (IS:2386 Part 2-1963)	1.4

4. Fly Ash

Fly ash is finely divided residue resulting from the combustion of coal that is in the powdered form and which transported flue gases and is collected by electrostatic precipitator. Fly ash is the most extensively used pozzolanic materials all over the world. In recent time, the importance and use of fly ash in concrete has grown greatly and recently it become one of the common ingredient in concrete, particularly for making high strength and high volume concrete. The use of fly ash as concrete admixture improves technical advantages to the properties of concrete and also it contributes to the environmental pollution control. In India alone, every year we produce about 75 million tons of fly ash and the disposal has become a serious environmental problem.

5. Lime Powder

Lime powder is a fine, white substance and is cheap. It is also known as hydrated lime or calcium hydroxide or slaked lime.

6. Polypropylene Fibre

Polypropylene is one of the thermoplastic polymer used in a wide variety of applications including packaging and labelling etc. Polypropylene has good resistance to fatigue.

Table -4: Properties of Polypropylene Fibre

<i>S.No</i>	<i>Property Table</i>	<i>Result</i>
1	Length of fiber	50mm
2	Diameter of fiber	0.6mm

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7. Steel Fibre

Steel fibres are of different types that is crimped, hooked, twisted, paddled ends, straight and ringed. Its diameter range from 0.25 to 0.76 mm. Use of steel fibre in concrete can improve its many properties.

Table –5: Properties of Steel Fibre

S.No	Property Table	Result
1	Length	42mm
2	Diameter	1.0mm

IV. RESULT AND DISCUSSIONS

1. COMPRESSIVE TEST RESULTS

Table -6: Average Compressive strength of M30 grade (15% LP, 0.8% Steel Fibre and 0.2% Polypropylene Fibre)

FLY ASH %	7 DAYS (N/mm ²)	14 DAYS (N/mm ²)	28 DAYS (N/mm ²)
0%	24.33	29.92	36.25
5%	26.25	32.94	40.38
15%	28.15	34.53	43.16
25%	26.95	33.16	41.45

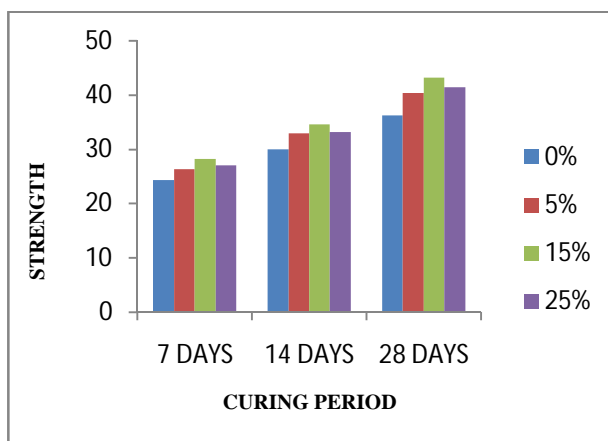


Fig 1: Compressive strength results

From the graph we can observe that the optimum percentage is at 15% that is, for 15% addition of fly ash along with 15% lime powder, 0.8% steel fibre and 0.2% polypropylene fibre, concrete gains maximum compressive strength and after 15% the strength will gradually decreases. Specimens were cured for 7, 14 and 28 days. 28 day specimens attain more strength when compared to 7 and 14 days.

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2. SPLIT TENSILE TEST RESULTS

Table - 7: Average Split tensile strength @ 7th 14th & 28th day

FLY ASH %	7 DAYS (N/mm ²)	14 DAYS (N/mm ²)	28 DAYS (N/mm ²)
0%	1.49	1.85	2.56
5%	1.95	2.46	3.27
15%	2.31	2.97	3.89
25%	2.16	2.68	3.34

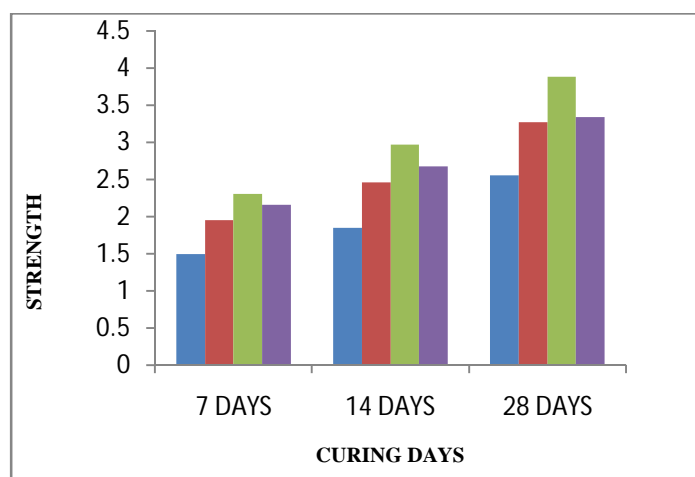


Fig 2: Split tensile strength results

From the above graph we can observe that the optimum percentage is at 15% that is, with 15% addition of fly ash along with 15% lime powder, 0.8% steel fibre and 0.2% polypropylene fibre, concrete gains maximum tensile strength and after 15% strength will gradually decreases. Specimens were cured for 7, 14 and 28 days. 28 day specimens attain more strength when compared to 7 and 14 days.

3. FLEXURAL STRENGTH RESULTS

Table - 8: Flexural strength @ 28th day Flexural Test

FLY ASH %	FLEXURAL STRENGTH (N/mm ²)
0%	4.38
5%	5.43
15%	6.36
25%	5.82

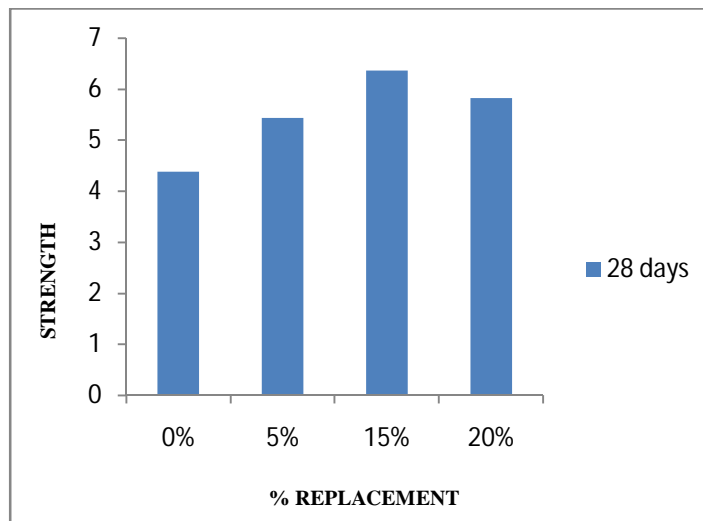


Fig 3: Flexural strength results

From the above graph we can observe that the flexural strength increases up to 24% with the addition of 5% fly ash, 15% lime powder, 0.8% steel fibre and 0.2% polypropylene fibre and there is an increase of 45% with the addition of 15% fly ash.

V. CONCLUSION

Due to addition of fly ash there is a considerable improvement in compressive strength of the concrete and due to the addition of steel fibre there is an improvement in tensile strength. With the replacement in concrete by fly ash the concrete prepared is greener concrete and also economical. The addition of fly ash considerably improves the workability of concrete. With the addition of steel fibres and fly ash in concrete ductility is improved considerably. The workability of high strength concrete improves with increase in fly ash content. Limestone powder has a greater surface area and the smooth texture and spherical shape of enhance inter particle friction and ensuring greater packing. The slump of concrete relatively increases with increase in lime powder content.

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