Experimental Investigation on Mechanical Properties of Hybrid Fibre Reinforced Concrete Due to the Influence of High Volume Fly Ash

D Nissi[1], K Venkatesh[2]

[1]Narasaraopeta Engineering College, Narasaraopeta, Andhra Pradesh, India
dnissi.amrut[at]gmail.com

[2]Narasaraopeta Engineering College, Narasaraopeta, Andhra Pradesh, India
venkateshkoppuravuri696[at]gmail.com

Abstract: ***Concrete is a material made out of Cement, Fine aggregate, Coarse aggregate and water. It is notable that assembling of one ton of Ordinary Portland Cement (OPC) assimilates 4GJ energy and produces about 0.75 to 1.0 ton of CO2 to the aerosphere. To add to a decrease of utilization of concrete around the world, industry wastages like Fly ash, Ground granulated slag, Silica seethe, Rice husk debris and so forth, have been started by scientists to supplant OPC in the solid. The concrete creation measure delivers a ton of carbon dioxide in air, which is the essential ozone depleting substance that causes a worldwide temperature alteration. Thus substitution of an extensive part of concrete by Fly ash can make a significant commitment towards tackling the worldwide temperature alteration issue. There has been an expansion in utilizing of High Volume Fly Ash Concrete (HVFAC) lately and various papers have been distributed. High Volume Fly Ash (HVFA) is commonly characterized as that with in any event half of the Portland concrete supplanted with fly debris. It is important to utilize super plasticizer on account of exceptionally low water content in High Volume Fly Ash concrete (HVFAC). Fiber reinforced concrete (FRC) is a concrete containing fibrous material which increases its structural integrity. The addition of Steel Fibers in concrete significantly increases its flexural toughness; energy absorption capacity, ductile behavior prior to the ultimate failure, reduced cracking, and improved durability. The Mechanical properties like Compressive strength, Flexural strength, Split tensile strength of high volume fly ash concrete reinforced with hybrid Fibres shows significant improvement of strength properties beyond 28 days.***

Keywords: High volume Fly ash concrete, Fibre Reinforced Concrete Compressive strength, Flexural Strength, Split Tensile strength

1. Introduction

Concrete is a development material made out of concrete, fine totals (sand) and coarse totals blended in with water which solidifies with time. Different kinds of cement have been created for expert application and have gotten known by specific names.

Fly Ash, being essentially pozzolanic, can really supplant a level of the Portland concrete, to deliver a more grounded, sturdier and greater climate agreeable cement. Fly Ash is acquired from burning of coal. Fly ash goes about as a Pozzolona when utilized as an advantageous cementitious material in concrete.

Fiber Reinforced Concrete contains short discrete strands that are consistently conveyed and haphazardly situated. Different types of fibres /filaments include steel strands, glass filaments, engineered filaments and regular filaments. Filaments/fibres are normally utilized in cement to control plastic shrinkage breaking and drying shrinkage breaking. They additionally bring down the porousness of cement and accordingly lessen seeping of water. Steel fiber (SF) is the most mainstream kind of fiber utilized as solid fortification.

2. Aim of the Research

The primary point of this examination is to contemplate the mechanical properties of high volume fly debris concrete strengthened with crossover Fibers. Tests are directed according to the Indian guidelines and test outcomes are broke down and contrasted and the control example that contains Hybrid Fiber strengthened High volume Fly debris solid, High volume Fly debris Concrete without any Fibers (non-sinewy cement), and Conventional cement. With the proper understanding of the acquired outcomes, it is possible to decide the ideal Fiber rate in high volume fly ash concrete (HVFAC).

2.1 Research Objectives

- Investigate the exhibition of mechanical properties of high volume fly debris concrete.
- Analyze the exhibition of mechanical properties of high volume fly debris concrete with steel Fiber and basalt Fiber in half breed structure.
- Explore the exhibition of mechanical properties of high volume fly debris concrete with steel Fiber and basalt Fiber in half breed structure.

2.2 Research Methods

The High volume Fly debris Concrete fortified (HVFAC) with Hybrid Fiber composites examples and control solid examples (non-sinewy cement) are tried for,

1) Compression quality test
2) Indirect elasticity test
3) Flexural quality test

3. 3. Properties of Materials

3.1 Fly ash

Fly debris is a heterogeneous side-effect material delivered in the burning cycle of coal utilized in power stations. It is a fine dim hued powder having round polished particles that ascent with the vent gases. As fly debris contains pozzolanic materials parts which reach with lime to frame cementitious materials. Consequently Fly debris is utilized in solid, mines, landfills and dams

3.2 Fibre Reinforced Concrete

Concrete is very well reasonable for a wide scope of uses. Notwithstanding, concrete has a few inadequacies as recorded beneath: 1) Low rigidity, 2) Low post-breaking limit, 3) Brittleness and low flexibility, 4) Limited exhaustion life, 5) Incapable of obliging huge distortions, and 6) Low effect quality. The presence of miniature breaks in the mortar-total interface is liable for the natural shortcoming of plain concrete.

The shortcoming can be taken out by incorporation of Fibers in the blend. Various kinds of Fibers, for example, those utilized in customary composite materials can be acquainted into the solid combination with increment its durability, or capacity to oppose break development. The Fibers help to move loads at the interior miniature breaks. Such a solid is called Fiber fortified cement.

3.3 Hybrid Fiber Reinforced cement

A composite can be expressed as a crossover when at least two kind of Fibers is utilized in a consolidated framework to deliver a composite that will mirror the advantage of every one of the individual Fiber utilized. This will at long last give a synergetic reaction to the entire structure. Such a composite of cement is named as the Hybrid Fiber Reinforced Concrete (HFC).

3.4 Steel Fibers

Steel fiber strengthened cement is a composite material that can be showered. It comprises of water driven concretes with steel Fibers that are scattered arbitrarily and have a rectangular cross-segment. The flexural quality of Fiber fortified cement is more prominent than the un-strengthened cement. Fortification of cement by steel Fibers is isotropic in nature that improves the protection from crack, deterioration, and exhaustion. Steel fiber fortified cement can withstand light and substantial burdens.

Figure 3.1: Steel Fibres

Figure 3.2: Types of Fibres

3.5 Basalt Fibers

Basalt Fiber is a nonstop Fiber made of softening basalt stone at 1450 to 1500 degrees through Platinum rhodium composite bushing. It is another ecological security Fiber which is known as the twenty-first Century 'volcanic rock silk', it is also called as Golden Fiber since its color is golden colored. It is like Fiberglass, having preferred physio mechanical properties over Fiberglass, however being essentially less expensive than carbon Fiber.

Figure 3.3: Basalt Fibres

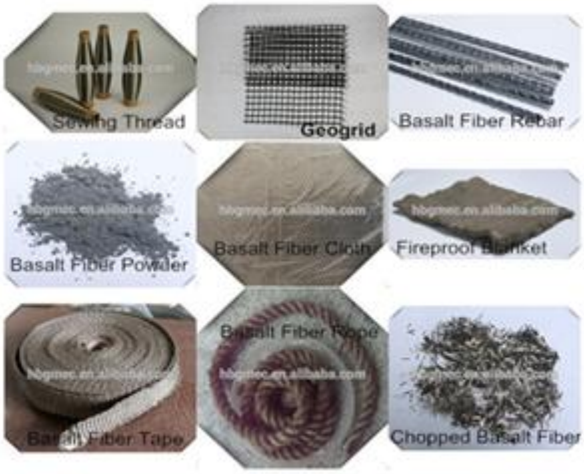

Figure 3.4: Types of Basalt Fibres

4. Mechanical and Physical Properties of Fibres

Property	Steel Fibre	Basalt Fibre
Length (mm)	40	12
Diameter	0.3mm	20µm
Tensile strength (MPa)	2100	3000- 4840
Specific gravity	7.6	2.65-2.8
Elastic modulus (GPa)	160	93 – 110
Density (g/cm^3)	7.8	1.75

5. Experimental Program

In the present test program, the initial step is choosing of crude materials. Number of traditional path is readied and the blend extents for M40 grade is chosen by changing diverse Water Cement proportions. By supplanting the concrete with fly debris in the scope of 40%, half, 60% and Hybrid Fibers (0.5, 0.75 and1%) are added for solid blend of concrete supplanted with fly debris as half. The trial program was done on 3D shapes, chambers and pillars.

6. Materials Used

The various materials utilized in the examination are:

6.1 Cement

Concrete utilized in the examination was discovered to be Ordinary Portland Cement (53 evaluation) affirming to IS: 12269 – 1987.

6.2 Fine Aggregate

The fine totals for the most part range from 0.075mm – 4.75mm. The fine total utilized in the present exploratory program was waterway sand. The Fine totals are chosen according to IS: 383 specifications.

6.3 Coarse aggregate

20 mm is the most extreme size of coarse total utilized in this test work and 12 mm is the base size of the total utilized. A decent nature of coarse total is gotten from closest smasher unit. The Coarse totals are chosen according to IS: 383 specifications.

6.4 Super Plasticizer (Master Glenium):

The Master Glenium SKY B233 item offering from BASF contains new age high-range water-decreasing admixtures that are exceptionally detailed for solid applications where droop maintenance, high/early qualities and solidness are required.

7. Testing of Specimens for Mechanical properties

The all around restored examples in relieving tank are tried for Compressive quality, part elasticity and Flexural Strength. By taking out the examples from the restoring tank, the examples were presented to daylight for surface drying. After the drying cycle, the examples are handled for testing. The examples are tried for 7, 28 and 90 days quality.

8. Concrete Mixture Composition

The extents of the control OPC solid combinations were 1:1.61:2.87.Table presents the creation of the solid blends delivered and tried: M1 blend is relating control Portland concrete solid; M2-M7 are High Volume Fly Ash Concrete combinations; M2 combination is made with 40% Fly debris substitution; M3 blend is made with half Fly debris substitution; M4 combination is made with 60% Fly debris substitution; M5 blend is made with half Fly debris substitution and expansion of 0.5% of steel Fibers and 0.5% of basalt Fibers by volume of cement; M6 blend is made with half Fly debris substitution and expansion of 0.75% of steel Fibers and 0.75% of basalt Fibers by volume of cement; M7 blend is made with half Flyash substitution and expansion of 1% of steel Fibers and 1% of basalt Fibers by volume of cement.

Table 6.1: Concrete Mixture Composition

Mix	M1	M2	M3	M4	M5	M6	M7
Cement (kg/m^3)	430	258	215	172	215	215	215
Fly Ash(kg/m^3)	-	172	215	258	215	215	215
F.A(kg/m^3)	692	692	692	692	692	692	692
C.A(kg/m^3)	124 5.58	124 5.58	124 5.58	124 5.58	124 5.58	124 5.58	124 5.58
W/C ratio	0.38	0.38	0.38	0.38	0.38	0.38	0.38
Super plasticizer (%)	0.62	0.62	0.62	0.62	0.62	0.62	0.62
Steel Fibres (%)	-	-	-	-	0.5	0.75	1
Basalt Fibres (%)	-	-	-	-	0.5	0.75	1

M1 - M40 Grade of Concrete.
M2 - High Volume Fly Ash Concrete with 40% of concrete Replaced with Fly Ash.

M3 - High Volume Fly Ash Concrete with half of concrete Replaced with Fly Ash.
M4 - High Volume Fly Ash Concrete with 60% of concrete Replaced with Fly Ash.
M5 - Hybrid Fiber Reinforced High Volume Fly Ash Concrete with half of concrete Replaced with Fly Ash and expansion of 0.5% of steel Fibers and 0.5% of basalt Fibres by volume of cement.
M6 - Hybrid Fiber Reinforced High Volume Fly Ash Concrete with half of concrete Replaced with Fly Ash and expansion of 0.75% of steel Fibers and 0.75% of basalt Fibers by volume of cement.
M7 - Hybrid Fiber Reinforced High Volume Fly Ash Concrete with half of concrete Replaced with Fly Ash and expansion of 1% of steel Fibers and 1% of basalt Fibres by volume of cement.

9. Experimental Test Results and Discussions

9.1 Compression Test

Compressive quality is gotten by applying smashing burden on the block surface. So it is likewise called as Crushing quality. Compressive quality of cement is determined by projecting 150mm x 150mm x 150mm shapes. The test outcomes are introduced here for the Compressive quality of 7, 28 and 90 days and of testing.

9.1.1 Compressive Strength of High Volume Fly Ash Concrete (No fibres)

Table 9.1: Compressive Strength of High Volume Fly Ash Concrete

Mixture number	Compressive Strength (N/mm^2)			% increase of strength from 28 days to 90 days
	7 Days	28 Days	90 Days	
M1	30.85	49.32	51.28	3.8
M2	17.23	25.52	39.23	37.23
M3	15.32	22.65	38.52	41.23
M4	14.52	20.23	35.56	41.65

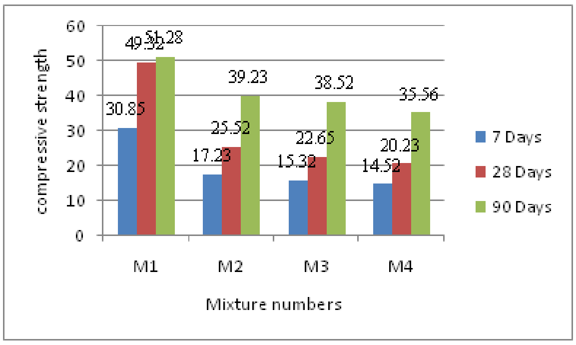

Figure 9.1: Compressive Strength of High Volume Fly Ash Concrete

9.1.2 Discussion of High Volume Fly Ash Concrete

Compressive strength of concrete mixtures of conventional, high volume fly ash concrete was determined at the ages of 7, 28, 90 days. Results are given in Table 9.1 and shown in Fig 9.1. At 28 days, control mixture M-1 (0% fly ash) achieved compressive strength of 49.32 MPa, whereas mixtures M-2 (40% fly ash), M-3 (50% fly ash), M-4 (60% fly ash) achieved compressive strength reduction of 50%, 55%, and 59% respectively, in comparison with the strength of the control mixture M-1 (0% fly ash). The results at 90 days indicated that there was continuous and significant improvement in strength beyond the age of 28days. The increase in strength from 28 to 90 days was between 37% and 42%. The significant increase in strength of high-volume fly ash concrete is due to pozzolanic reaction of fly ash.

9.1.3 Compressive Strength of Hybrid Fibre Reinforced High Volume Fly Ash Concrete

Table 9.2: Compressive Strength of Hybrid Fibre Reinforced High Volume Fly Ash Concrete

Mixture number	Compressive Strength (N/mm^2)			% increase of strength from 28 to 90 days
	7 Days	28 Days	90 Days	
M1	30.85	49.32	51.28	3.8
M5(0.5% of hybrid Fibres)	20.32	28.85	39.26	28.35
M6(0.75% of hybrid Fibres)	26.28	32.58	46.29	31.56
M7(1% of hybrid Fibres)	24.35	30.58	44.25	30.25

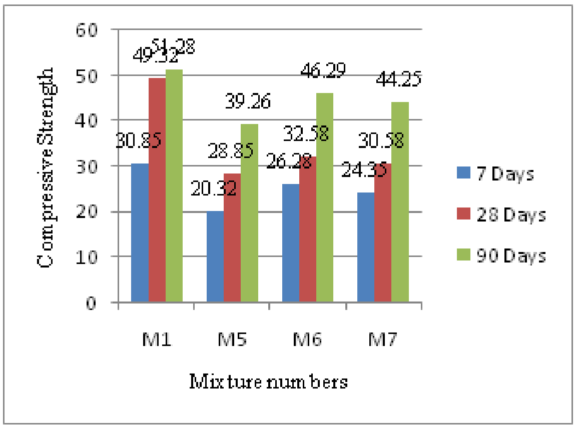

Figure 9.2: Compressive Strength of Hybrid Fibre Reinforced High Volume Fly Ash Concrete

9.1.4 Discussion of Hybrid Fibre reinforced High Volume Fly Ash Concrete

Compressive strength of concrete mixtures of conventional, and hybrid reinforced high volume fly ash concrete was determined at the ages of 7, 28, 90 days. Results are given in Table9.2 and shown in Fig 9.2. At 28 days, control mixture M-1 (0% fly ash) achieved compressive strength of 49.32 MPa, whereas mixtures M-5 (50% flyash and 0.5% of hybrid Fibres), M-6 (50% flyash and 0.75% of hybrid Fibres), M-7 (50% flyash and 1% of hybrid Fibres) achieved compressive strength reduction of 42%, 35%, 37% respectively, in comparison with the strength of the control mixture M-1 (0% fly ash) and strength increased as compared to High volume fly ash concrete mixture M-3(50% fly ash).. The results at 90 days indicated that there was continuous and significant improvement in strength beyond the age of 28days. The increase in strength from 28 to 90 days is nearly 30%. The increase in strength is, of course, due to the cement that continued to hydrate. The significant increase in strength of high-volume fly ash concrete is due to pozzolanic reaction of fly ash and due to hybrid Fibres used in it.

9.2 Split Tensile Strength Test

For split tensile strength test standard cylinder size of dia 150mm and height of 300mm are used. An average of three specimens is taken for all mixes after a curing period of 7, 28 and 90 days.

9.2.1 Split Tensile Strength of High Volume Fly Ash Concrete (No fibres)

Table 9.3: Split Tensile Strength of High Volume Fly Ash Concrete

Mixture number	Splitting Tensile Strength (N/mm^2)			% increase of strength from 28 days to 90 days
	7 Days	28 Days	90 Days	
M1	2.65	4.87	5.45	9.5
M2	1.88	4.45	4.95	10.85
M3	1.65	4.23	4.85	11.54
M4	1.55	4.10	4.55	7.23

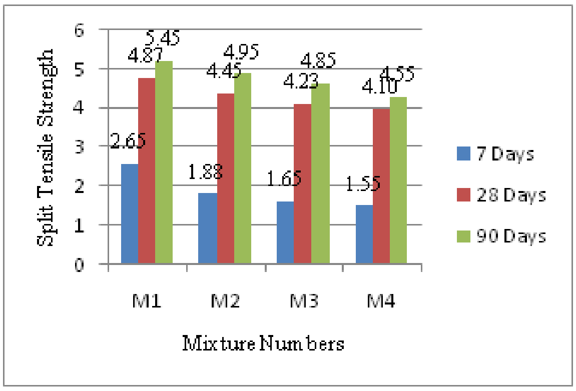

Figure 9.3: Split Tensile Strength of High Volume Fly Ash Concrete

9.2.2 Discussion of High Volume Fly Ash Concrete

Split tensile strength of concrete mixtures of conventional and high volume fly ash concrete was determined at the ages of 7, 28, 90 days. Results are given in Table 9.3 and shown in Fig 9.3. At 28 days, control mixture M-1 (0% fly ash) achieved Split tensile strength of 4.87 MPa, whereas mixtures M-2 (40% fly ash), M-3 (50% fly ash), M-4 (60% fly ash) achieved split tensile strength reduction of nearly 10% to15% respectively, in comparison with the strength of the control mixture M-1 (0% fly ash). The results at 90 days indicated that there was continuous and significant improvement in strength beyond the age of 28days. The increase in tensile strength from 28 to 90 days nearly 10%.

9.2.3 Split Tensile Strength of Hybrid Fibre Reinforced High Volume Fly Ash Concrete

Table 9.4: Split Tensile Strength of Hybrid Fibre Reinforced High Volume Fly Ash Concrete

Mixture number	Splitting Tensile Strength (N/mm^2)			% increase of strength from 28 days to 90 days
	7 Days	28 Days	90 Days	
M1	2.65	4.87	5.45	9.5
M5(0.5% of hybrid Fibres)	2.45	4.85	8.98	46.23
M6(0.75% of hybrid Fibres)	3.52	5.25	9.85	47.55
M7(1% of hybrid Fibres)	3.10	5.10	9.25	46.56

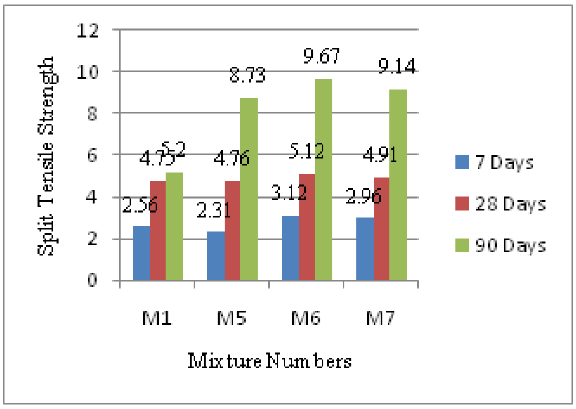

Figure 9.4: Split Tensile Strength of Hybrid Fibre Reinforced High Volume Fly Ash Concrete

9.2.4 Discussion of Hybrid Fibre reinforced High Volume Fly Ash Concrete

Split tensile strength of concrete mixtures of conventional and hybrid reinforced high volume fly ash concrete was determined at the ages of 7, 28, 90 days. Results are given in Table 9.4 and shown in Fig 9.4. At 28 days, M-1 (0% fly ash) achieved Split tensile strength of 4.87 MPa, whereas mixtures M-5 (50% fly ash and 0.5% of hybrid Fibres), M-6 (50% fly ash and 0.75% of hybrid Fibres), M-7 (50% fly ash and 1% of hybrid Fibres) achieved split tensile strength 5-10% more in comparison with the strength of the M-1 (0% fly ash) and strength increased as compared to High volume fly ash concrete mixture M-3(50% fly ash). At the 90 days of curing the split tensile strength is increased by nearly 80% as compared with conventional concrete and high volume fly ash concrete due to presence of Fibres.

9.3 Flexural Strength Test

For Flexural strength test standard prism of size 100mm x 100mm x 500mm are used. An average of 3 specimens is taken for all mixes after a curing period of 7, 28 and 90 days.

9.3.1 Flexural Strength of High Volume Fly Ash Concrete (No fibres)

Table 9.5: Flexural Strength of High Volume Fly Ash Concrete

Mixture number	Flexural Strength (N/mm^2)			% increase of strength from 28 days to 90 days
	7 Days	28 Days	90 Days	
M1	2.85	4.98	5.85	14
M2	2.25	4.45	5.52	18
M3	2.15	4.24	5.24	20
M4	2.13	3.99	4.98	20

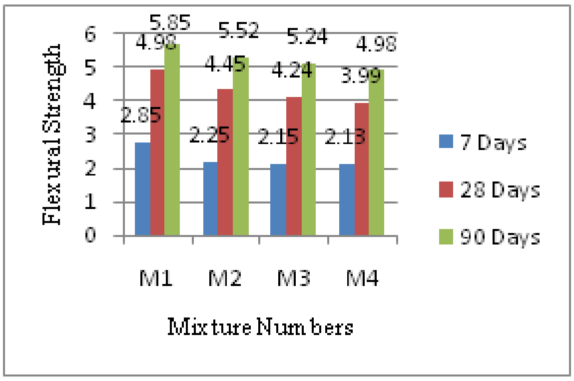

Figure 9.5: Flexural Strength of High Volume Fly Ash Concrete

9.3.2 Discussion of High Volume Fly Ash Concrete

Flexural strength of concrete mixtures of conventional and high volume fly ash concrete was determined at the ages of 7, 28, 90 days. Results are given in Table 9.5 and shown in Fig 9.5. At 28 days, control mixture M-1 (0% fly ash) achieved flexural strength of 4.98 MPa, whereas mixtures M-2 (40% fly ash), M-3 (50% fly ash), M-4 (60% fly ash) achieved flexural strength reduction of nearly 15% to20% respectively, in comparison with the strength of the control mixture M-1 (0% fly ash). The results at 90 days indicated that there was continuous and significant improvement in strength beyond the age of 28days. The increase in flexural strength from 28 to 90 days nearly 20%.

9.3.3 Flexural Strength of Hybrid Fibre Reinforced High Volume Fly Ash Concrete

Table 9.6: Flexural Strength of Hybrid Fibre Reinforced High Volume Fly Ash Concrete

Mixture number	Flexural Strength (N/mm^2)			% increase of strength from 28 days to 90 days
	7 Days	28 Days	90 Days	
M1	2.85	4.98	5.85	14
M5(0.5% of hybrid Fibres)	2.59	4.85	8.99	50
M6(0.75% of hybrid Fibres)	2.56	4.95	10.55	45
M7(1% of hybrid Fibres)	2.54	4.85	9.55	50

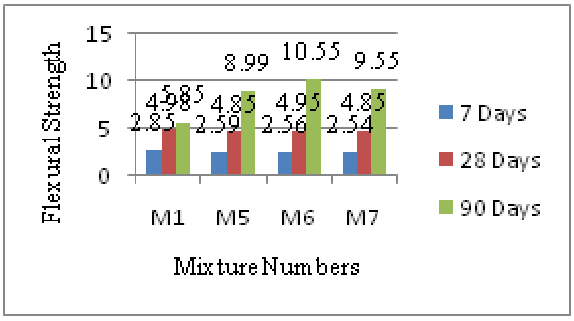

Figure 9.6: Flexural Strength of Hybrid Fibre Reinforced High Volume Fly Ash Concrete

9.3.4 Discussion of Hybrid Fibre reinforced High Volume Fly Ash Concrete

Flexural strength of concrete mixtures of conventional and hybrid reinforced high volume fly ash concrete was determined at the ages of 7, 28, 90 days. Results are given in Table 9.6 and shown in Fig 9.6. At 28 days, M-1 (0% fly ash) achieved Flexural strength of 4.98 MPa, whereas mixtures M-5 (50% fly ash and 0.5% of hybrid Fibres), M-6 (50% fly ash and 0.75% of hybrid Fibres), M-7 (50% fly ash and 1% of hybrid Fibres) achieved flexural strength 15-20% more in comparison with the strength of the control mixture M-1 (0% fly ash) and strength increased as compared to High volume fly ash concrete mixture M-3(50% fly ash). At the 90 days of curing the flexural strength is increased by nearly 70% as compared with conventional concrete and high volume fly ash concrete due to presence of Fibres.

10. Conclusion

The accompanying ends are gotten from this trial examination.

- The supplanting of concrete with three rates (40%, half, and 60%) of fly debris content decreased the compressive quality, Split elasticity, and Flexural quality of cement at 28 days of restoring however there was a nonstop and critical improvement of solidarity properties past 28 days.
- The setting season of fly debris concrete expanded related to the expansion of fly debris content.
- Compressive quality of halfway supplanting of concrete with half fly debris fortified with 0.75% steel Fiber and 0.75% basalt Fiber in crossover structure was found to have been expanded by 20% in 90 days contrasted with fractional supplanting of concrete with half fly debris without adding Fibers.
- Indirect rigidity of halfway supplanting of concrete with half fly debris strengthened with 0.75% steel Fiber and 0.75% basalt Fiber in crossover structure was found to have been expanded by 50%in 90 days contrasted with incomplete supplanting of concrete with half fly debris without adding Fibers.
- Flexural quality of incomplete supplanting of concrete with half fly debris strengthened with 0.75% steel Fiber and 0.75% basalt Fiber in cross breed structure was found to have been expanded by 50%in 28 days

contrasted with fractional supplanting of concrete with half fly debris without adding Fibers.

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- IS 383-1970: Specifications for Coarse Aggregate And Fine Aggregates From Natural Sources of Concrete.
- IS: 2386-1963: Methods of Testing Aggregates for concrete.
- IS: 456-2000: Design Specifications of Plain and Reinforced Concrete.
- IS: 10262-2009: Recommended rules for Concrete Mix Design.
- IS 516-1959: Methods of Test for quality of Concrete.