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# Experimental Investigation on Hybrid Fibre Reinforced Concrete with Partial Replacement of Cement by Silica Fume and Quartz Powder

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**ABSTRACT**: Adding fibres to concrete greatly increases the toughness of the material. The use of fibres also alters the behaviour of the fibre matrix composite after it has cracked, thereby improving its toughness Secondary cementing materials like Reactive Powder can be used to partially replace cement because of pozzolanic nature. Materials like quartz powder best suites to sand due to its physical and chemical properties, fineness etc. Also these materials are known to increase durability, resistance to sulphate attack. Our main aim is study the materials Quartz powder, Silica Fume are best suitable for preparing durability of concrete for M40 Grade. In cement replaced by silica fume and quartz powder with various percentages like 10%, 15% and 20%. And additional strength purpose using crimped steel fibres and banana fibre with various percentages like 0%, 0.5%, 1%, and 1.5%. This study investigates mechanical properties like compressive strength, Split tensile strength, flexural strength and Durability properties like Acid attack test, Sulphate attack test and Alkalinity attack test and the comparative study of normal concrete and fibres concrete.

KEYWORDS: Steel fibre, Banana fibre, Silica fume, Quartz powder.

# I. INTRODUCTION

Concrete is a composite material composed of coarse aggregate bonded together with fluid cement that hardens over time. Most concretes used are lime-based concretes such as Portland cement concrete or concretes made with other hydraulic cement such as cement found. However, asphalt concrete which is frequently used for road surface, is also a type of concrete, where the cement material is bitumen, and polymer concretes are sometimes used where the cementing material is a polymer. When aggregate is mixed together with dry Portland cement and water, the mixture forms fluid slurry that is easily poured and moulded into shape. The cement reacts chemically with the water and other ingredients to form a hard matrix that binds the materials together into a durable stone-like material that has many uses. Often, additives (such as pozzolons or super plasticizer) are included in the mixture to improve the physical properties of the wet mix or the finished material. Most concrete is poured with reinforcing materials. It provides superior fire resistance compared with wooden construction and gains strength over time. Structures made of concrete can have a long service life. Concrete is used more than any other manmade material in the world. Crimped steel fibre are low carbon, cold drawn steel wire fibers designed to provide concrete with temperature and shrinkage crack control, enhanced flexural reinforcement, improved shear strength and increase the crack resistance of concrete. Crimped Steel Fiber complies with ASTM C1116, Standard Specification for Fiber Reinforced Concrete and Shotcrete and ASTM



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A820, Type I, and Standard Specification for Steel Fibers for Fiber Reinforced Concrete. These steel macrofibers will also improve impact, shatter, and fatigue and abrasion resistance while increasing toughness of concrete.BananaFiber Reinforced Concrete The capability of durable structure to resist weathering action, chemical attack, abrasion and other degradation processes during its service life with the minimal maintenance is equally important as the capacity of a structure to resist the loads applied on it.. Recently, however the development of Banana fiber-reinforced concrete has provided a technical basis for improving these deficiencies. Quartz, most common of all minerals is composed of silicon dioxide, or silica, SiO<sub>2</sub>. Specimens are transparent; others are translucent. In pure form, quartz is colourless, but it is commonly coloured by impurities. Rock crystal is a colourless form of quartz occurring in distinct crystals. This paper presents an overview of the effects of hybrid fibres (banana fibre and steel fibre) and hybrid fibre with partial replacement of silica fume and quartz powder on various properties of concrete in fresh and hardened state such as workability, compressive strength, tensile strength, flexural strength. The main objective of this study as follows

- ✓ To study the different strength parameters like compressive strength, tensile strength, flexural strength and durability of hybrid fibre reinforced concrete with different mix proportion of fibers
- ✓ To study the different strength parameters like compressive strength, tensile strength, flexural strength and durability of hybrid fibre reinforced concrete with partial replacement of cement by silica and quartz powder in different proportions.
- ✓ To know the optimum percentage of addition of fibers to concrete and finding maximum hybrid ratio and optimum percentage of addition of silica fume and quartz powder to concrete.

#### II. MATERIALS

2.1	Ce	ment	
	1	<b>T</b>	

1.	Type of cement	: OPC 53
2.	Specific gravity of cement	: 3.15
3.	Fineness of cement	: 8%
4.	Compressive strength of mortar cube (7days)	: 38 N/mm <sup>2</sup>
5.	Compressive strength of mortar cube (28days)	: 54 N/mm <sup>2</sup>

# 2.2 Coarse aggregates

In this research investigation crushed grained aggregate of 12mm size was used.

1.	Specific gravity of	: 2.75
2.	Sieve analysis	: Zone II
3.	Fineness modulus	: 3.11
4.	Flakiness Index	: 14%
5.	Elongation Index	: 24.09%
6.	Aggregate impact value	: 28.57%
7.	Aggregate crushing value	: 23.27%

#### 2.3 Fine aggregate

In this research M-Sand was used as fine aggregate. The specific gravity of is found to be 2.65

# 2.4 Hybrid fibres

- 1. Crimped steel fibers with aspect ratio 50.
- 2. Banana fibre with aspect ratio 50.

# 2.5 Silica fume

Silica fume is an ultrafine material with spherical particles less than  $1\mu m$  in diameter, the average being about 0.15  $\mu m$ . This makes it approximately 100 times smaller than the average cement particle.



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# 2.6 Quartz powder

The addition of quartz powder in concrete leads to reduction in porosity of the transition zone between matrix and aggregate in the fresh concrete and provides the microstructure needed for a strong transition zone.

# **III. MIX DESIGNATION**

- CM : 100% Cement(M40)
- HF1 : 0.25% S. F + 0.25%B.F
- HF2 : 0.5% S.F + 0.5% B.F
- HF3 : 0.75% S.F + 0.75 % B. F
- OHF : Optimum Hydrid Ratio
- M1 : OHF+ 90% Cement+ 5% Silica Fume+ 5% Quartz powder
- M2 : OHF+ 85% Cement+ 7.5% Silica Fume+ 7.5% Quartz powder
- M3 : OHF+ 80% Cement+ 10% Silica Fume+ 10% Quartz powder

# IV. MIX DESIGN - M40

# **Table 1.Mix proportion**

Cement	Fine aggregate	Coarse aggregate	Water
478.17kg/m <sup>3</sup>	659.07 kg/m³	1075.34kg/m <sup>3</sup>	215.18kg/m <sup>3</sup>
1	1.3	2.2	0.45

# V. RESULTS AND DISCUSSION

# 5.1 Slump Test

Slump test is used to determine the workability of fresh concrete. The slump measured should be recorded in mm of subsidence of the specimen during the test.

# Table 2. Slump values for various mixes

Type of mix	CM	HF1	HF2	HF3	M1	M2	M3
Slump value	78	76.4	74	72.5	70.6	67.8	64

# **5.2** Compressive strength of concrete

The table 3 shows the result of compressive strength test after 28days of curing. The optimum hybrid ratio is HF2. Result shows that the % increase in the compressive strength is higher with the addition of 1.0 % steel hybrid fibre with 15% silica fume and quartz powder.



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#### Table 3. Compressive strength after 28 days

Type of Mix	Si No	% of fibre	% of silica fume and quartz powder	Type of specimen	Compressive strength $Load$ $Area$
					( N/mm <sup>2</sup> )
Normal Concrete	1	0	0	СМ	41.11
Hybrid fibre reinforced	2	0.5	0	HF1	44.88
concrete	3	1.0	0	HF2	46.22
	4	1.5	0	HF3	43.55
Hybrid reinforced concrete	5	1.0	10	M1	47.11
with silica fume and quartz	6	1.0	15	M2	47.77
powder	7	1.0	20	M3	46.88

From Fig 1 at 28 days of curing, the compressive strength of concrete mixture increases by 12.43% for HF2 and 16.20% for M2. Result shows that the % increase in the compressive strength is higher with the addition of 1.0 % steel fibre and banana fibre with 15% silica fume and quartz powder. However, hybridisation improves the compressive strength marginally as compared to normal concrete.



Fig 1 Comparison of HF concrete and HF with silica fume and quartz powder

#### 5.3 Flexural strength test

The table 4 shows the results of flexural strength test after 28days of curing. The optimum hybrid ratio is HF2 and maximum strength on M2.

Type of Mix	Si No	% of fibre	% of silica fume	Type of	Flexural strengt
		noic	and quartz powder	speemen	
					( N/mm <sup>2</sup> )
Normal Concrete	1	0	0	СМ	6.25
Hybrid fibre reinforced concrete	2	0.5	0	HF1	7
	3	1.0	0	HF2	7.5
	4	1.5	0	HF3	7.25
Hybrid reinforced concrete with silica fume and quartz powder	5	1.0	10	M1	8
	6	1.0	15	M2	8.25
	7	1.0	20	M3	7.7

#### Table 4. Flexural strength



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From Fig. 2, at 28days of curing, the flexural strength of concrete mixture increases by 20% for HF3 and 32% for M2. Hybridization keeps improving the flexural strength as compared to normal concrete.



# 5.4 Split tensile strength test

The table 5 shows the result of split tensile strength test after 28days of curing. The optimum hybrid ratio is HF2. Result shows that the % increase in the split tensile strength is higher with the addition of 1.0 % steel hybridfibre with 15% silica fume and quartz powder.

Type of Mix	Si No	% of fibre	% of silica fume and	Type of specimen	Split tensile strength
			quartz powder	1	0
					( N/mm² )
Normal Concrete	1	0	0	CM	4.159
Hybrid fibre reinforced	2	0.5	0	HF1	5.781
concrete	3	1.0	0	HF2	6.838
	4	1.5	0	HF3	5.992
Hybrid reinforced concrete	5	1.0	10	M1	6.909
with silica fume and quartz	6	1.0	15	M2	7.339
powder	7	1.0	20	M3	7.191

# Table 5. Split tensile strength test

From 3, at 28 days of curing, the split tensile strength of concrete mixture increases by 64.41% for HF2 and 76.46%. Hybrid fibres improve the split tensile strength noticeably as compared to normal concrete. concrete having more split tensile strength on 1.0% fibers+ 15% silica fume and quartz powder.



Fig 3 Comparison of HF concrete and HF with silica fume and quartz powder



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#### 5.5 Acid attack test

The table 6 shows the result of acid attack test after 56days and 90 days of curing. The optimum hybrid ratio is HF2 and optimum mix is M2.

Type of Mix	Si	% of	% of silica fume	Type of	Compressive strength	
	No	fibre	and quartz powder	specimen	$\frac{Load}{Area}$ (N/mm <sup>2</sup> )	
					56 Days	90 Days
Normal Concrete	1	0	0	CM	38.44	32.66
Hybrid fibre reinforced concrete	2	0.5	0	HF1	42.22	36.22
	3	1.0	0	HF2	43.77	37.77
	4	1.5	0	HF3	41.11	35.77
Hybrid reinforced concrete with	5	1.0	10	M1	44.22	38.22
silica fume and quartz powder	6	1.0	15	M2	45.11	38.88
	7	1.0	20	M3	43.11	35.33

Table 6. Acid attack test

From Fig 4, Acid attack test is having more strength on 1.0% fibers+ 15% silica fume and quartz powder. In this Acid Attack Test strength at 56 days increases 13.86 % for HF2 and 17.35% for M2 when compared with conventional concrete. The loss of strength is 6.49% for CM, 5.30% for HF2 and 5.56% for M2. In this Acid Attack Test strength at 90 days increases 15.64 % for HF2 and 19.04% for M2 when compared with conventional concrete. The loss of strength is 20.55% for CM, 18.28% for HF2 and 18.610% for M2.



Fig.4Comparison of HF concrete and HF with silica fume and quartz powder

# 5.6 Alkalinity attack test

The table 7 shows the result of alkaline attack test after 56days and 90 days of curing. The optimum hybrid ratio is HF2 and optimum mix is M2.

Type of Mix	Si No	% of fibre	% of silica fume and quartz	Type of specimen	Compressive strength $\frac{Load}{Area}$ (N/mm <sup>2</sup> )	
			powder		56 Days	90 Days
Normal Concrete	1	0	0	СМ	37.77	32.88
Hybrid fibre reinforced	2	0.5	0	HF1	41.77	36.44
concrete	3	1.0	0	HF2	43.55	38.00
	4	1.5	0	HF3	41.33	35.55
Hybrid reinforced concrete	1	1.0	10	M1	44.00	38.44
with silica fume and quartz	2	1.0	15	M2	4488	38.66
powder	3	1.0	20	M3	43.33	35.11

#### Table 7.Alkaline attack test



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From Fig 5, In this alkaline attack test strength at 56 days increases 15.303% for HF2 and 18.82% for M2 when compared with conventional concrete. The loss of strength is 8.12% for CM, 5.77% for HF2 and 6.04% for M2. In this alkaline attack test strength at 90 days increases 15.57% for HF2 and 17.57% for M2 when compared with conventional concrete. The loss of strength is 20.01% for CM, 17.78% for HF2 and 19.07% for M2.



Fig 5 Comparison of HF concrete and HF with silica fume and quartz powder

#### 5.7 Sulphate attack

The table 8 shows the result of Sulphateattack test after 56days and 90 days of curing. The optimum hybrid ratio is HF2 and optimum mix is M2.

Type of Mix	Si No	% of fibre	% of silica fume and quartz	Type of specimen	Compressive strength $\frac{Load}{Area}$ (N/mm <sup>2</sup> )	
			powder		56 Days	90 Days
Normal Concrete	1	0	0	CM	38.22	32.88
Hybrid fibre reinforced concrete	2	0.5	0	HF1	41.77	38.88
	3	1.0	0	HF2	42.88	40.44
	4	1.5	0	HF3	39.55	35.11
Hybrid reinforced concrete with silica fume and quartz powder	1	1.0	10	M1	44.00	40.88
	2	1.0	15	M2	44.88	42.66
	3	1.0	20	M3	42.66	39.55

#### Table 8. Sulphate attack test

From Fig 6, In this Sulphate attack test strength at 56 days increases 12.19% for HF2 and 17.42% for M2 when compared with conventional concrete. The loss of strength is 7.02% for CM, 7.22% for HF2 and 6.04% for M2. In this Sulphate attack test strength at 90 days increases 22.99% for HF2 and 29.74% for M2 when compared with conventional concrete. The loss of strength is 20.02% for CM, 12.50% for HF2 and 10.69% for M2.



Fig 6 Comparison of HF concrete and HF with silica fume and quartz powder



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# VI. CONCLUSION

- Crimped Steel Fibers are used low carbon cold drawn steel wire fibers designed to provide concrete with temperature and shrinkage crack control, improved shear strength crack resistance of the concrete.
- As addition of fibers is increasing there is a decrease in the slump values. From this we can conclude that as the percentage of fiber content is increased the workability will be decreased.
- Compressive strength of concrete having more strength on 1.0% fibers+ 15% silica fume and quartz powder.
- Flexural strength of concrete having more strength on 1.0% fibers+ 15% silica fume and quartz powder.
- Split tensile strength of concrete having more strength on 1.0% fibers+ 15% silica fume and quartz powder.
- Acid attack test is having more strength on 1.0% fibers+ 15% silica fume and quartz powder. In this Acid Attack Test strength at 56 days increases 13.86 % for HF2 and 17.35% for M2 when compared with conventional concrete. In this Acid Attack Test strength at 90 days increases 15.64 % for HF2 and 19.04% for M2 when compared with conventional concrete.
- Alkalinity test is having more strength on 1.0% fibers+ 15% silica fume and quartz powder. In alkaline attack test strength at 56 days increases 15.303% for HF2 and 18.82% for M2 when compared with conventional concrete. In alkaline attack test strength at 90 days increases 15.57% for HF2 and 17.57% for M2 when compared with conventional concrete.
- Sulphate attack test is having more strength on 1.0% fibers+ 15% silica fume and quartz powder. In Sulphate attack test strength at 56 days increases 12.19% for HF2 and 17.42% for M2 when compared with conventional concrete. In Sulphate attack test strength at 90 days increases 22.99% for HF2 and 29.74% for M2 when compared with conventional concrete.

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