STUDY ON HIGH STRENGTH HIGH PERFORMANCE HYBRID FIBER REINFORCED CONCRETE

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ABSTRACT

Now-a-days most of the structures are failed due to the micro cracks .The main reason of that failure is due to inadequate strength of the concrete .In this experiment, high strength high performance hybrid fiber reinforced concrete is used to reduce the micro cracks failure. In this project high strength concrete m60 is used. It is designed by different design methods, IS 10262 2009, Trial mix method and literature survey.In order to increase the performance of high strength concrete one or more cementitious materials are used. In this experiment Micro silica and Quartz powder are used to increase the performance of the concrete with different proportions by increasing 5% by weight of cement. It is well known that the increasing percentage of micro silica gives increasing the strength of concrete. By combining both, it gives best results. After finding the effective percentage of cementitious materials, hybrid fibres are added.Hybrid fiber reinforced concrete is formed by a combination of different fibers, which differ in properties remain bonded together when added in concrete and retain their identities and properties. In this experiment two different fibres such as steel fiber and nylon fiber is used for different proportions(0.25% 0.5% and 0.75 %). These two fibres have different properties and these properties will increase the compressive, tensile, flexural strength of concrete and water absorption decreases.The results shows that the strength of the concrete is improved.

Keyword : high strength concrete , micro silica , quartz powder , steel fiber , nylon fiber.

1.INTODUCTION:

The term fiber reinforced concrete (FRC) is defined as a concrete made of hydraulic cements containing fine or fine and coarse aggregates and discontinuous discrete fibers. Inherently concrete is brittle under tensile loading. Mechanical properties of concrete can be improved by reinforcement with randomly oriented short discrete fibers, which prevent and control initiation, propagation, or coalescence of cracks. FRC can continue to sustain considerable loads even at deflections exceeding fracture deflections of plain concrete. The character and performance of FRC changes depending on matrix properties as well as the fiber material, fiber concentration, fiber geometry, fiber orientation, and fiber distribution.. . A composite can be termed as hybrid, if two or more types of fibers are rationally combined to produce a composite that derives benefits from each of the individual fibers and exhibits a synergetic response. Reinforcement of concrete with a single type of fiber may improve the properties to a limited level. However by using the concept of hybridization with two or more different types of fibers incorporated in a common cement matrix, the hybrid composite can offer more attractive engineering properties because the presence of one fiber enables the more efficient utilization of the potential properties of the other fiber.A composite can be termed as hybrid, if two or more types of fibres are rationally combined in a common matrix to produce a composite that drives benefits from each of the individual's fibres and exhibits a synergetic response. Addition of short discontinuous fibres plays an important role in the improvement of mechanical properties of Concrete. It increases elastic modulus; decreases brittleness controls cracks initiation and its subsequent growth and propagation.. The term 'High Performance' is somewhat pretentious because the essential feature of this concrete is that its ingredients and proportions are specifically chosen so as to have particularly appropriate properties for the expected use of the structure such as high strength and low permeability. Hence High performance concrete is not a special type of concrete. It comprises of the same materials as that of the conventional cement concrete. The use of some mineral and chemical admixtures like Micro Silica and Super plasticizer enhance the strength, durability and workability qualities to a very high extent.High Performance Concrete works out to be economical, even though it's initial cost is higher than that of conventional concrete because the use of High Performance Concrete in construction enhances the service life of the structure and the structure suffers less damage which would reduce overall costs. In HSHPFRC the fibers are much finer: they are already activated when micro cracks occur in the concrete. It may therefore be wondered whether those fine fibers act as reinforcement, or whether they are an integral part of the composite on a lower (micro) level. The fine fibers react immediately on micro cracking in the concrete.

2. LITERATURE REVIEW:

HYBRID FIBER REINFORCED CONCRETE (HYFRC): FIBER SYNERGY IN HIGH STRENGTH MATRICES, Banthia.N and Gupta.R (2004) This paper deals with the level of synergy achieved by hybridization of fibers in the concrete matrices. In most cases, fiber reinforced concrete (FRC) contains only one type of fiber. The use of two or more types of fibers in a suitable combination may potentially not only improve the overall properties of concrete, but may also result in performance synergy. The combining of fibers, often called hybridization, is investigated in this paper for a very high strength matrix of an average compressive strength of 85 MPa. Control, single, two-fiber and three fiber hybrid composites were cast using different fiber types such as macro and micro-fibers of steel, polypropylene and carbon. Flexural toughness tests were performed and results were extensively analyzed to identify synergy, if any, associated with various fiber combinations. Based on various analysis schemes, the paper identifies fiber combinations that demonstrate maximum synergy in terms of flexural toughness.

DESIGN OF HIGH STRENGTH CONCRETE MIXES M60 AND INVESTIGATION OF ITS STRENGTH PARAMETER, D.Ramesh, S.Murali, S.Balaji and V.Ganesan (2015)Concrete is the basic engineering material used in most of the civil engineering structures. Its popularity as basic building material in construction is because of its economy , good durability and ease with which it can be manufactured at site .The ability to mould it into any shape and size , because of its plasticity in green stage and its subsequent hardening to achieve strength , its particularly useful concrete like other engineering materials needs to be designed for properties like strength , durability , workability and cohesion .Concrete mix design is the science of deciding relative proportions of ingredients of concrete , to achieve the desired properties in the most economical way . Design of concrete Mix deign requires complete knowledge of the various properties of these constituents materials the implications in case of these conditions at the site , the impact of the properties of plastic concrete on the hardened concrete and the complicated inter-relationship between the variables . Even then the proportions of the materials of the concrete found at the laboratory require modification and readjustments to suit the field calculation. In this design project we have designed M60 grade concrete using Design mix of American Concrete Institute method and also found out compression strength for design mix method.

EFFECT ON MECHANICAL PROPERTIES OF CONCRETE USING NYLON FIBERS Dr.S.K.Verma (2016)**.** This paper presents the results of an experimental study for enhancing compressive strength, split tensile strength and flexural strength of concrete using nylon fibers with volume fractions (Vf) of 0.5%, 1.0% and 1.5% were used. Cubes, cylinders and beams were casted with different volume fractions. The samples with added nylon fibers of 1% showed better results in compressive strength and split tensile strength, 1.5% for flexural strength.

FLEXURAL STRENGTH OF ULTRA HIGH STRENGTH CONCRETE BEAMS REINFORCED WITH STEEL FIBERS" I.H.Yang (2011**)** The purpose of this paper is to examine the basic behavior of high strength concrete beams reinforced with steel fibers. The experimental parameters included steel rebar ratio less than 0.02 and the method of placing high performance concrete. The high strength concrete did not use coarse aggregate and had a volumetric ratio of 2%. The experimental test results from static loading of the beams revealed the characteristics of flexural behavior of the steel fiber-reinforced high strength concrete. Flexural behavior included cracking, failure pattern, deflection, ductility, and flexural strength measurements. The test results from this study provide more information to help establish a prediction model for the flexural strength and deflection of ultra high strength concrete beams under bending conditions.

"STUDY ON THE FLEXURAL PROPERTIES OF METALLIC-HYBRID-FIBER REINFORCED CONCRETE" Rashid Hameed, et al. (2010**),**. The experimental results obtained with Fiber-Reinforced Concrete containing high-bonding amorphous metallic steel fiber delays the formation of micro-cracks and results in high peak load whereas carbon steel hook-ended fiber contributes towards the flexural toughness (energy absorption capacity) by bridging macro-cracks in the post peak region. The test results on hybrid-fiber-reinforced concrete show that the two metallic fibers when used in hybrid form result in superior performance compared to their single-fibre reinforced counterparts. Superior performance as a result of fiber hybridization is interpreted as a positive synergetic effect between the fibers.

"PERFORMANCE EVALUATION OF HYBRID FIBER REINFORCED CONCRETE MATRIX Patodi.S.C, et al.(2012),**".** This paper presents experimental investigation on different volume fractions of Recron 3S fibers (polyester fibers) and continuously crimped steel fibers to produce HFRC and gives its performance under compression, tension, flexure, shear and impact types of loading. The optimum fiber ratio of Recron and steel fibers for HFRC matrix was found to be 0.3: 0.7 for overall better performance in terms of strength and post-peak ductility. This ratio also indicated the best resistance against impact and toughness.

"COMPARATIVE FLEXURAL BEHAVIOR OF ULTRA HIGH PERFORMANCE CONCRETE REINFORCED WITH HYBRID STRAIGHT STEEL FIBERS" ,Jung Jun Park (2017) . This study investigates the implications of fiber hybridization on the flexural behavior of Ultra-High-Performance Concrete (UHPC). To do this, we considered three straight steel fibers with different lengths, *lf*, of 13mm (short), 19.5mm (medium-length), and 30mm (long) at various volume fractions. Test results indicated that the hybrid use of long and medium-length fibers effectively improved the flexural performance in terms of post-cracking strength, deflection capacity, toughness, and cracking behavior, whereas the hybrid use of long and short fibers generally decreased the performance. To verify this observation, a micromechanical analysis was performed for obtaining the fiber bridging curve, which most significantly influences the post-cracking properties. The hybrid use of long and short (or medium-length) fibers provided negative synergy values in toughness due to several detrimental effects. The complementary energy in the fiber bridging curve increased with an increase in the fiber length, so that an increase in the proportion of short (or medium-length) fiber clearly decreased the complementary energy. Based on a proposed equation for the relationship between the normalized modulus of rupture and the fiber reinforcing index, we found that it is possible to produce deflection-hardening behavior of UHPC with straight steel fibers when the fiber reinforcing index is higher than 0.5.

"EXPERIMENTAL INVESTIGATION ON HIGH PERFORMANCE CONCRETE USING SILICA FUME AND SUPERPLASTICIZERS " P.Vinayagam (2012) , This paper formulates a simplified mix design procedure for HPC by combining BIS and ACI Code methods of mix design and available literature on mixes are arrived at. These HPC mixes are tested experimentally for compression, split tensile, flexure and workability. The performance of the design mixes are very good and the results are reported are in this paper. The durability characteristics of HPC are under progress.

3. EXPERIMENTAL METHODOLOGY

LITERATURE REVIEW

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MATERIALS COLLECTION AND IDENTIFICATION OF MATERIAL PROPERTIES

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MIX DESIGN AND CASTING OF SPECIMEN WITH MICRO SILICA AND QUARTZ POWDER

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EFFECTIVE % OF MICRO SILICA AND QUARTZ POWDER ARE FOUND

↓

OPTIMIZING THE MICRO SILICA , QUARTZ POWDER AND FIBERS (STEEL & NYLON)

↓

CASTING AND TESTING OF SPECIMEN

↓

RESULTS AND CONCLUSIONS

MATERIALS

CEMENT:

The Ordinary Portland Cement of 53 grades conforming to IS 12269 – (1987) was used in this study. The specific gravity, initial and final setting of OPC 53 grade were 3.15, 30 and 600min, respectively. The table 3.1 shows the properties of cement,

Properties of Cement

PROPERTY	**RESULTS**
Specific gravity	3.15
Consistency	31 %
Initial setting time	30 minutes
Final setting time	600 minutes

FINE AGGREGATE :

Aggregate is a granular material,

properties of fine aggregate :

PROPERTY	VALUE
Specific Gravity	2.6
Fineness Modulus	3.25
Water Absorption	1.0%
Grading zone	III

3.2.3:COARSE AGGREGATE :

A majority of the volume of concrete (60 – 80%) is occupied by aggregate.

Properties of Coarse Aggregate

PROPERTIES	**VALUE**
Specific gravity	2.61
Fineness modulus	7.81
Water absorption	0.5%
Maximum size of aggregate	20 mm
Type of aggregate	Crushed angular

MICRO SILICA:

Micro silica is an amorphous (non-crystalline) polymorph of silicon dioxide , The average particle diameter of 150 nm.

PROPERTIES OF MICRO SILICA

PROPERTY	VALUE
Particle size	< 2μm
Specific gravity	2.22
Surface area	13,000 – 30,000 m^2/kg

QUARTZ POWDER

Quartz Powder is used as reactive powder for the replacement on cement.

PROPERTIES OF QUARTZ POWDER

PROPERTY	**VALUE**
Specific gravity	2.65
Colour	White
Melting point	1700°C

STEEL FIBER

Steel Fibers are generally distributed throughout a given cross section whereas reinforcing bars or wires are placed only where required.

Properties Of Crimped Steel Fiber

PROPERTY	**VALUE**
Diameter	0.9 to 1.1mm
Specific gravity	7800kg/m^3
Tensile strength	1000 to 2000Mpa
Young's modulus	200Gpa
Aspect ratio	40 to 60
Ultimate elongation	5 to 10 %
Thermal conductivity	2.74

NYLON FIBER:

The Nylon Fiber is used in variety of applications owing to its high strength, resilience and durability but its disposal poses a serious threat in environment.

Properties of Nylon Fiber

PROPERTY	**VALUE**
Tensile strength	1200N/mm^2
Elongation	12%
Diameter	0.7mm
Length	45-60mm
Aspect ratio	65-85

Sulphonated naphthalene formaldehyde resin used as a super plasticizer.

MIX DESIGN

Details of Mix Proportion:

cement (kg/m^3)	**fine aggregate (kg/m^3)**	**coarse aggregate (kg/m^3)**	**water (lit/m^3)**	**super plasticizer (lit/m^3)**
1	1.80	2.11	0.3	8
466	840	987	140	8

various mix design using micro silica and quartz powder

In this procedure the Micro Silica and quartz powder are added with increasing 5% in there content.And found the effective percentage.

EXPERIMENTAL INVESTIGATION

SLUMP TEST

The slump measured shall be recorded in terms of millimeter of subsidence of the specimen during the test .

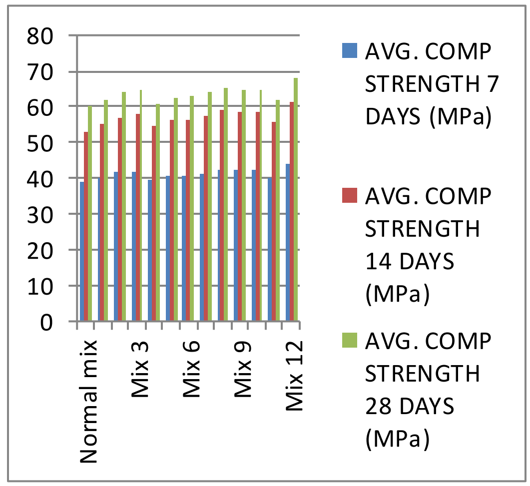
HARDENED TESTS:. Cubes of size 150*150*150mm are used for testing compressive strength of concrete, are casted with M60. Cylinders of diameter 150mm and length 300mm are casted to test split tensile strength,. Prism of size 100*100*500mm are used to find flexure strength of concrete. Super plasticizer is used for the M60 grade of concrete. The specimens were remolded after 24 hours after curing. i.e.7 days , 14 days and 28 days.

compressive strength

Compressive strength is one of the most important properties of concrete and influences many other describable properties of the hardened concrete. Average Compressive test results for 7,14,28 days.

Mix	7 days (MPa)	14 days (MPa	28 days (MPa)
Normal mix	39	53	60
Mix1(M 5%,Q 0%)	40.3	55	62
Mix 2(M 10%, Q 0%)	41.6	57	64
Mix 3(M 15 % , Q 0%)	41.9	58	64.5
Mix 4(M 0% , Q 5%)	39.6	54.9	61
Mix 5(M 0%,Q 10%)	40.6	56.2	62.5
Mix 6(M 0%,Q 5%)	40.8	56.5	62.8
Mix 7(M 5% ,Q 15%)	41.5	57.5	63.9
Mix 8(M 10%,Q 10%)	42.5	58.9	65.5
Mix 9 (M 15%,Q 5%)	42.1	58.3	64.8
Mix 10(M 20%,Q 0%)	42.2	58.4	64.9
Mix 11(M 0 %,Q 20%)	40.1	55.6	61.8
Mix 12(M 5%,Q 5%)	44.3	61.2	68.1

Graph:1: MIX PROPORTIONS vs AVG.COMP.STRENGTH



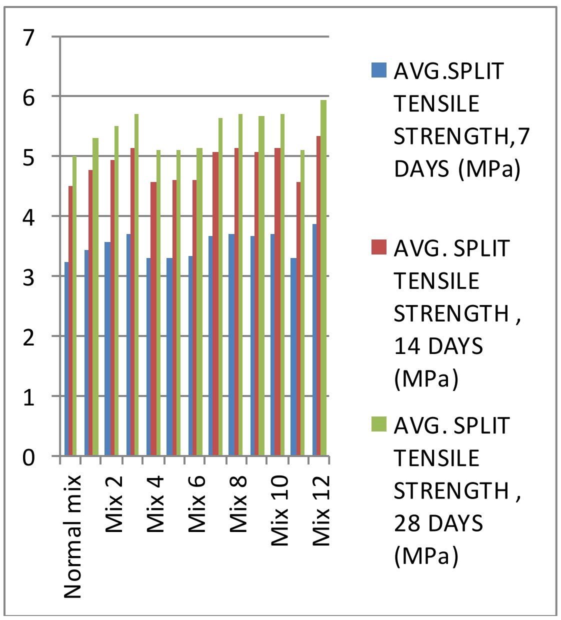
SPLIT TENSILE STRENGTH

Testing for split tensile strength of concrete is done as per IS 5816-1959[6]. The test is conducted on compression testing machine of capacity 2000kN.Average split tensile result shows,

Mix	7 days (MPa)	14 days (MPa)	28 days (MPa)
Normal mix	3.25	4.5	5
Mix 1	3.44	4.77	5.3
Mix 2	3.57	4.95	5.5
Mix 3	3.70	5.13	5.7
Mix 4	3.31	4.59	5.1

Mix 5	3.32	4.61	5.12
Mix 6	3.33	4.62	5.13
Mix 7	3.67	5.08	5.65
Mix 8	3.70	5.13	5.7
Mix 9	3.68	5.09	5.66
Mix 10	3.72	5.14	5.72
Mix 11	3.32	4.59	5.11
Mix 12	3.86	5.35	5.95

Graph 2:Mix proportion vs avg.split Tensile strength

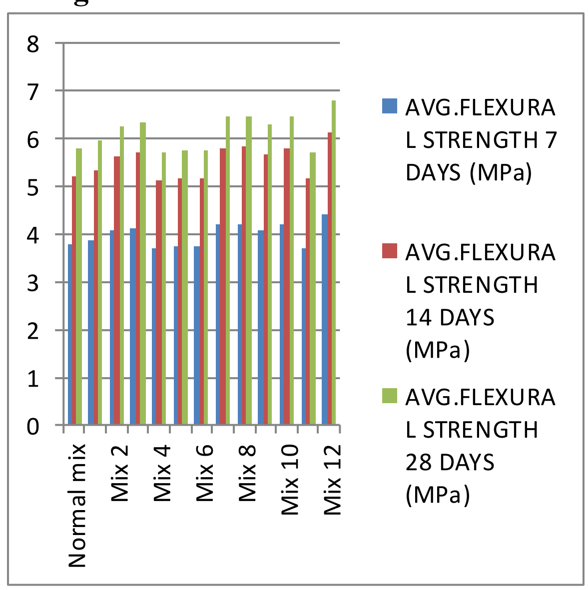


FLEXURAL STRENGTH Specimen of standard dimension of 100mm*100mm*500mm over a span of 400mm, under symmetrical two-point loading.Table 3 shows avg.flexural strength,

MIX	7 DAYS (MPa)	14 DAYS (MPa)	28 DAYS (MPa)
Normal	3.77	5.22	5.8

mix			
Mix 1	3.87	5.35	5.95
Mix 2	4.06	5.62	6.25
Mix 3	4.13	5.71	6.35
Mix 4	3.7	5.13	5.7
Mix 5	3.74	5.18	5.76
Mix 6	3.73	5.17	5.75
Mix 7	4.19	5.80	6.45
Mix 8	4.21	5.83	6.48
Mix 9	4.09	5.67	6.3
Mix 10	4.19	5.80	6.45
Mix 11	3.72	5.15	5.72
Mix 12	4.42	6.12	6.8

Graph 3:Mix proportion vs avg . flexural strength



The optimum percentage of microsilica and quartz powder is 5% and 5% respectively.i.e.,MIX 12

In this ratio ,use different percentage of steel and nylon fibers to determine effective ratio of HSHPHFRC**.**

MIX PROPORTION:

From the optimum of micro silica and quartz powder, the fibers like steel and nylon fibers are introduced in concrete by varying percentage of 0.25 %, 0.5 % and 0.75 %.

Table 4:various mix proportion of steel and nylon fiber:

s. no:	percentage of steel fiber	percentage of nylon fiber
Mix A	0.25	0.75
Mix B	0.5	0.5
Mix C	0.75	0.25

To find optimum percentage of fibers,introduce different ratios of fibers in optimum value of cementitious materials (micro silica 5% and quartz powder 5%). With the help of mechanical properties,

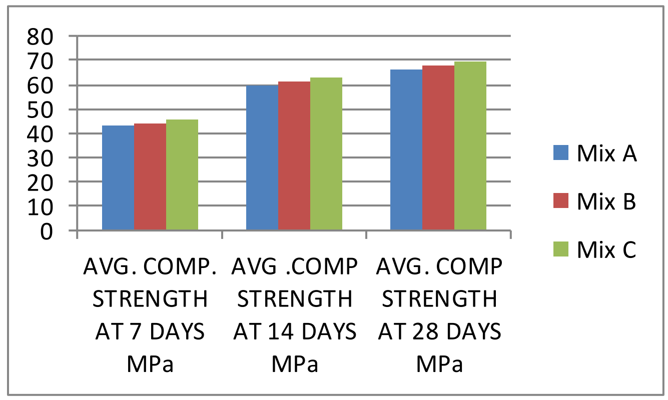
compressive strength:

Compressive strength is carried out for 150mm*150 mm*150mm.

Table5: Compressive strength results :

S.NO	7 DAYS MPa	14 DAYS MPa	28 DAYS MPa
Mix A	43.2	59.8	66.5
Mix B	44.1	61.1	67.9
Mix C	45.3	62.8	69.8

Graph 4 mix prop.of fibers vs avg comp strength



SPLIT TENSILE STRENGTH:

The tensile splitting strength was determined

$Ft = 2P / \pi D Lc$

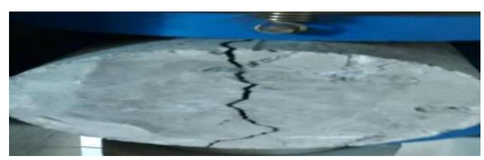
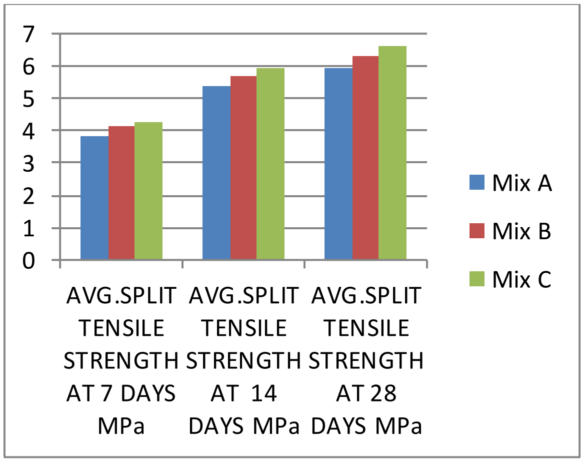


Table 6:avg. split tensile strength:

S.NO:	7 DAYS MPa	14 DAYS MPa	28 DAYS MPa
Mix A	3.86	5.35	5.95
Mix B	4.13	5.7	6.3
Mix C	4.29	5.94	6.6



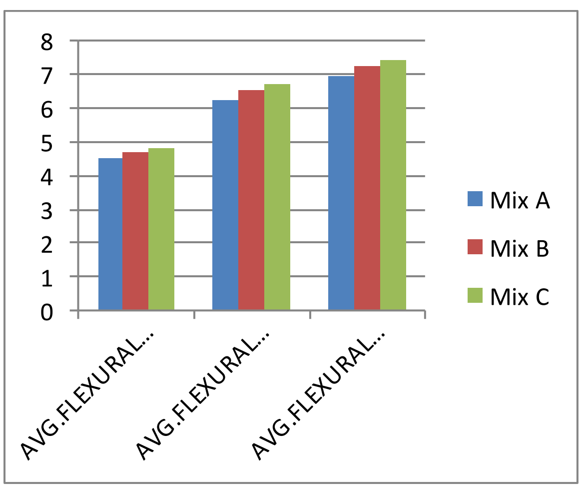
FLEXURAL STRENGTH:

The flexural strength of specimen is calculated by PL/bd^2 .

Table 7: Flexural strength:

S.NO:	7 DAYS MPa	14 DAYS MPa	28 DAYS MPa
Mix A	4.51	6.25	6.95
Mix B	4.7	6.52	7.25
Mix C	4.84	6.70	7.45

Graph 6 :mix proportion v avg. flexural strength



The graph shows average flexural strength at 7 , 14 , 28 days respectively.and the flexural testing fig . shows below

DURABILITY TEST:

Durability of concrete plays a critical role in controlling its serviceability. This test method is used to determine the rate of absorption (sorptivity) of water .

Sorpitivity test :

The absorption test was conducted using 150 mm cubes that were cured for 28 days. The specimens were weighed at oven dry condition and wet condition and thus the water absorption were determined .

% water absorption = {(B – A)/A}*100

Where ,

A = weight of oven dry test piece in grams

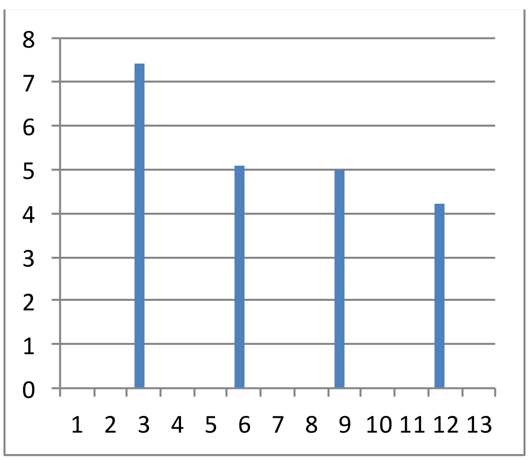
B = weight of saturated surface dry test piece in grams

Table 8:Water Absorption results:

s.no	Tl no	wt.of cube before oven kg	wt. of cube after oven kg	% absorption	avg
nor	1	8.47	7.85	7.89	

mal mix	2	8.35	7.75	7.74	7.44
	3	8.75	8.20	6.71	
Mix A	1	8.65	8.38	3.22	5.08
	2	8.5	8.00	6.25	
	3	8.45	7.99	5.76	
Mix B	1	8.52	8.20	3.9	4.99
	2	8.30	7.85	5.73	
	3	8.48	8.05	5.34	
Mix C	1	8.46	8.10	4.44	4.23
	2	8.65	8.35	3.60	
	3	8.35	7.98	4.64	

Graph 7. water absorption vs mix proportions



Water absorption and mix proportions are present in graph at y and x axis respectively.

4.CONCLUSIONS:

Based on experimental investigation ,the total conclusions are,

By conducting experimental investigation on various design mixes (M60) (Mix 1 to Mix 12) Micro Silica and Quartz Powder are optimized. Mix 1, 2, 3, shows a cumulative increase in strength, but combining micro silica and quartz powder gives more strength than other mix proportion.

As observed in mechanical properties of various mix proportion, mix 12 (Micro Silica 5%, Quartz Powder 5%) gives the maximum optimum value in the trial of different mix proportions. Mix 12 is considered as a optimum value for introducing the fibers. And the properties of fibers are studied in the application of introducing in the optimum value. The percentage of 0.75 % and 0.25 % gives the effective value.

As well as compressive value, split tensile, flexural values , water absorption are also higher when compared with other mix proportion. Thus overall observation of this study shows that it advantageous to use High strength High Performance Hybrid Fiber Reinforced Concrete mix (0.75 % steel fiber and 0.25 % nylon fiber) with (5% Micro Silica + 5% of Quartz Powder) which gives satisfactory results in all conducted tests for concrete Grade M60.

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