EXPERIMENTAL INVESTIGATION ON NYLON FIBER AND FLY ASH REINFORCED M40 GRADE OF CONCRETE

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ABSTRACT: This paper presents experimental study on investigation of nylon fiber and fly ash reinforced M40 grade of concrete . Review will be done on nylon fiber reinforced concrete by partial replacement of cement with fly ash and fine aggregate with nylon fiber. Nylon fiber is like small pieces of reinforcing material which has very useful applications like high strength, durability, tensile strength .It reduces money and time. Fiber reduces water content and acts as a crack arrester. Nylon fiber will shrink in length and expand in diameter when heated and also it has high strain and low thermal conductivity. Fly ash will reduces the depletion of natural resources and reduces the weight criteria. Grouting powder is used as fastener. It is a concrete in fluid form used to fill voids. Grouting powder has impermeability and high adhesion properties. In the design 8%, 10%,12% of nylon fiber, 10%, 20%, 30% of fly ash, and in& average of 8% of grouting powder is added. The properties like compressive strength, tensile strength, flexural strength were tested. The investigation is to increase the compressive strength, split tensile strength, flexural strength by the comparision between BIS and ACI methods.

KEY WORDS: Cement, Nylon fiber, Fly ash, Grouting powder.

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1. INTRODUCTION:-

Nylon fiber reinforced concrete is a composite material comprising of cement, sand, coarse aggregate, water, nylon fiber and fly ash. In this composite material, short discrete filaments are arbitrarily conveyed all through the solid mass. The conduct effectiveness of this composite material is far better than that of plain concrete and numerous other development materials of equivalent cost. Because of this advantages, the utilization of Nylon fiber reinforced concrete has steadily expanded and its present field of use incorporates expressway asphalts, connect deck overlays, water driven structures, burrow linings, earth-quake resistant, explosive resistant structures, slope stabilization etc.

Utilization of Nylon fiber likewise recalibrates the conduct of the fiber-grid composite after it has broken through enhancing its toughness. A numerical parameter portraying a fiber as its perspective proportion or aspect ratio, which is characterized as fiber length, isolated by an equal fiber width [1/d]. Run of the fiber perspective proportion [1/d] run from 30 to 150 for length measurements of 0.1 to 7.62cm run of the typical fiber diameter are 0.25 to 0.76mm.

Fly ash is a gathering of materials that can shift fundamentally in organization. It is deposit left from consuming coal. The fineness of fly ash debris is basic on the grounds that the impact of rate of pozzolanic movement and usefulness of cement. Fly ash remains has a tendency to add to solid quality at a quicker rate when these parts are available in better divisions of fly ash. Substance more prominent than this may add to soluble base total extension issues. (Fly ashes tends to contribute to concrete strength at a faster rate when these components are present in finer fractions of fly ash. Contents greater than this may contribute to alkali-aggregate expansion problems.)

The Grouting powder goes about as an admixture. It is a cementious material, which has an ability to fill voids between the composite materials. A huge lessening in split width and break dispersing is conceivable, particularly at early ages. They have a high rigidity and a high versatile modulus. These are accessible at moderately low expenses. Admixtures are there to reduce the water content by reducing the surface tension of water and increase the durability of concrete, decrease the thermal cracking.

It is obviously in the behavior of hybrid fiber reinforced concrete depends on distribution, aspect ratio, geometrical shapes and mechanical properties of fiber in concrete mixture. The distribution and orientations of fiber effect the properties of Nylon fiber reinforced concrete such as toughness, strength, durability and width of crack.

1.1 Material Properties :-

1.Cement
2.Coarse aggregate
3.Fine aggregate
4.Nylon fiber
5.Fly ash
6.Grouting powder
7.Water

1.1.1 CEMENT :-

Ordinary Portland Cement of 43 grade has been used in the experimental investigation. The specific gravity of cement is 3.15, standard consistency of 30%. The initial setting time of this cement is 45 minutes and final setting time 120 minutes. The fly ash replacement of cement.

1.1.2. COARSE AGGREGATE :-

Locally available crushed stone aggregate of size 20mm are used with specific gravity 2.7, water absorption of 0.5%, fineness modulus of 7.2, The range for fineness modulus of coarse aggregate varies from 5.5 to 8 for all sizes of the aggregate 20mm size aggregate used up to 60% and 10mm size aggregate used up to 40% which are retained on 4.75mm IS sieve. Both 20mm and 10mm aggregates are used because to avoid the voids and make the concrete easy for mixing and increase the ease of flow in the concrete mixes.

1.1.3. FINE AGGREGATE :-

The fine aggregate with specific gravity 2.65, water absorption value is 2%, fineness modulus of 3.62. The range for fineness modulus of zone-2 fine aggregate confining to IS: 383-1970 is varies from 3.37 to 2.1. The specific gravity and water absorption of the fine aggregate is determined by the procedure followed by IS: 2386 part(3)-1963. The nylon fiber replacement of fine aggregate.

1.1.4. NYLON FIBER :-

1. Material : virgin fiber (Nylon fiber)
2. Colour : White
3. Length of the fiber : 3/4inch
4. Specific gravity : 0.85
5. Water absorption : 3.5%
6. Chemical resistance : Good
7. Electric conductivity : Low
8. Thermal conductivity : Low

Figure-1: Nylon fiber

1.1.5. FLY ASH :-

Fly ash, taken from local area, has a specific gravity of 2.2. The frost resistance coefficient of 0.85.

Figure-2: Fly ash

1.1.6.Water :-

Portable water from tap is used for concrete casting and curing process as per IS456:2000 specifications. Water cement ratio of 0.40, 0.47 was used in the preparation of concrete and for this purpose portable water used for mixing and curing purpose.

1.1.7.Grouting powder:-

The expansion coefficient is approximately 0.2. The grouting powder gives foams whose bubbles have a diameter not exceeding 1mm.The formation of the foam may take 10 to 20 minutes, sometimes longer. Raising the temperature reduces this time and increases the expansion coefficient. The viscosity increases, expressed in seconds. The setting time is about 35 to 45 seconds. It increases rigidity, reduces the distances along which the grout flows in the fissures.

Figure-3: Grouting powder

2.LITERATURE REVIEW :-

2.1. K. Manikandan etc. has worked on" Experimental Investigation On Nylon Fiber Reinforced Concrete". In the designed concrete the sand was admixture with 2%, 4%, 6% of Nylon fiber. The compressive strength, flexural strength, tensile strength are studied and compared with conventional concrete. The strength is increased along with the addition of nylon fiber. The specimen cast with 2%,4%,6% nylon fiber replacement by fine aggregate gives better compressive strength, split tensile strength, flexural strength.(i.e., average of 1.15%)

2.2.J.D. Chaitanya Kumar has worked on " Experimental studies on fiber reinforced concrete". In compressive strength, flexural strength, split tensile strength, the addition of steel fiber the strength is linearly increasing, but in glass fiber up to 1% it is increasing and from 2% it is decreasing. The strength is increasing up to on 1%. After 1% the strength is reducing. The FRC is added 0.5,1,2 and 3% are added for M20 grade concrete. Result shows the percentage increase in compressive strength, flexural strength and split tensile strength for 28 days.

2.3.E. siva subramanian etc has worked on "Experimental investigation of concrete composite using nylon fiber". The nylon fiber reinforced concrete has far better strength than normal concrete .Mix designs of concrete has 0%,1%, 2%, 3% of nylon fiber. The result shows the effect of nylon fiber on concrete has a considerable amount of increase in compressive and split tensile characteristics. By addition of 1% nylon of total volume of concrete achieves more strength than that of normal concrete.

2.4.Jaya Saxena has worked on "Enhancement The Strength Of Conventional Concrete By Using Nylon Fiber". The nylon fiber is used in 0.2%, 0.25%, 0.3% of volume of concrete the result obtained by the compressive strength is increased. In conventional concrete, cement is replaced by 10%, 20%, 30% with fly ash. In conventional concrete 10% fly ash, 90% cement and 0.2%, 0.25% and 0.3% nylon fiber getting good strength of concrete.

2.5.Arul Raj C. has worked on "Experimental investigation on flexural behaviour of steel fiber and nylon fiber reinforced concrete beam". In this study examines the flexural strength of concrete with two different types of fiber such as steel fiber and nylon fiber with fiber content of 0.75% of steel fiber is kept constant in each mix and 0.50%, 0.75% of nylon fiber was varied in each mixes. The maximum increase in tensile strength observed at having steel fiber ratio 0.75% in M25 grade and M30 grade and compared with conventional concrete the increase in tensile strength with addition of fiber in 0.50%, 0.75%, of nylon fiber and 0.7% of steel fiber. Flexural strength may be maximum for steel 0.75% when compares to conventional concrete. The maximum increase in compressive strength observed at having steel fiber ratio 0.75% in M25 and M30 grade.

2.6.Vikrant S.Vairagade etc., has worked on "Experimental investigation on hybrid fiber reinforced concrete". The compressive strength between S0.6P0.4 & S0.7P0.3 is increase high as compared to conventional concrete. The split tensile strength gives high strength. To maintain the slump value constant, super plasticizers has been increased in concrete.

2.7.Amit Rai has worked on "Applications and properties of fiber reinforced concrete". Here, steel fibers, glass fibers, polymer fibers, natural fibers are used. By using these fibers, strength, abrasion resistance, toughness, permeability increases. The addition of fibers increases shear capacity of reinforced concrete beams up to 80%. Addition of randomly distributed fibers increases shear friction strength, crack strength, ultimate strength. The most important contribution of fiber reinforcement in concrete is not to strength but to the flexural toughness of the material. Fiber reinforced concrete is generally made with a high cement content and low water/cement ratio respectively.

2.8.Jeongsoo Nam etc., has worked on "Effectiveness of fiber reinforcement on the mechanical properties and shrinkage cracking of recycled fine aggregate concrete". A small fiber volume fraction, such as 0.05% r 0.1% in RFAC with ployvinyl alcohol or nylon fibers was used for optimum efficiency in minimum quantity. The surface crack area of fiber-reinforced concrete was significantly reduced according to increasing fiber volume fraction compared to that of nylon. The reason for this behavior can be explained by the improvement in the bond between the cement matrix and coarse aggregate due to added fibers. It was determined that the effectiveness of added fibers at a small volume fraction in recycled fine aggregate concrete with 100% fine aggregate replacement is significant for the reduction of surface cracks rather than for improvement of mechanical performance.

2.9.V. S. Parameswaran etc., has worked on "Current research and applications of fiber reinforced concrete composites in India". Natural fibers have also proved effective and useful in making low-cost roofing sheets and tiles, their use in housing construction projects is increasing. The application has not yet caught up with its repute.

3. EXPERIMENTAL METHODOLOGY:-

The concrete mix design was done in accordance to IS:10262(1982). In this project M40 is used. The mix ratio of 1:1.3:2.7 as per BIS method and the mix ratio of 1:2.04:2.52 as per ACI method. By using this proportion value the volume of cement, fine aggregate, coarse aggregate, nylon fiber, fly ash are estimated. The normal portland concrete (OPC 43 GRADE), stone aggregate and regular sand of Zone-2 was utilized as coarse aggregate and fine aggregate. For this study of cubes (150*150*150mm), cylinder (150mm dia and 300mm height) were casted by the replacement of cement by fly ash (10%,20%,30%) and the fine aggregate by nylon fiber (8%,10%,12%). Then further tests are conducted and it will be casted. The cubes and cylinders are used for calculating compressive strength and split tensile strength respectively.

TABLE-1: QUANTITIES OF MATERIALS

M40 Grade of concrete mix in BIS Method	
Materials	**Quantity**
Cement	400kg/m^3
Fine aggregate	585.44kg/m^3
Coarse aggregate	1244.06kg/m^3
Water content	180kg/m^3
w/c	0.40
Grouting powder	8%

TABLE-2: QUANTITIES OF MATERIALS

M40 Grade of concrete mix in ACI Method	
Materials	**Quantity**
Cement	394 kg/m^3
Fine aggregate	803kg/m^3
Coarse aggregate	992kg/m^3
Water content	185kg/m^3
w/c	0.47
Grouting powder	8%

TABLE-3: QUANTITIES OF NYLON FIBER AND FLY ASH

S.No.	CATEGORY	NYLON FIBER		FLY ASH	
		BIS	ACI	BIS	ACI
1.	Category (8N+10F)%	46.83	64.24	40	39.4
2.	Category (8N+20F)%	46.83	64.24	80	78.8
3.	Category (8N+30F)%	46.83	64.24	120	118.2
4.	Category (10N+10F)%	58.54	80.3	40	39.4
5.	Category (10N+20F)%	58.54	80.3	80	78.8
6.	Category (10N+30F)%	58.54	80.3	120	118.2
7.	Category (12N+10F)%	70.25	96.36	40	39.4
8.	Category (12N+20F)%	70.25	96.36	80	78.8
9.	Category (12N+30F)%	70.25	96.36	120	118.2

TESTING OF HARDENED CONCRETE:

1. Compressive strength test.
2. Split tensile strength test.
3. flexural strength.

4. TEST RESULTS AND ANALYSIS:

4.1.COMPRESSIVE STRENGTH TEST:

For compressive strength test, cube specimens of dimensions 150*150*150mm were cast for M40 grade of concrete in BIS and ACI method of mix design proportions. The moulds were filled with concrete in three layers and compacted using a tamping rod. Further, the moulds were placed on the vibrating table for 60 seconds to achieve proper compaction and subsequently maintained on a plane and level surface in the laboratory for 24 hours. The cubes were demoulded and set aside for curing. The compressive strength was calculated as follows,

Compressive strength (MPa) = $^{\text{Failure load}}/_{\text{Area of cross section}}$ (N/mm^2)

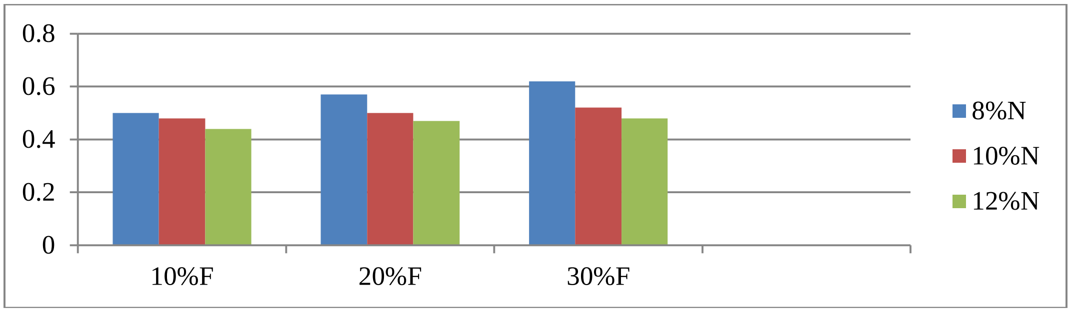
TABLE-4: COMPRESSIVE STRENGTH VALUES IN BIS METHOD

S.No.	NYLON FIBER	MIX	FAILURE LOAD (KN)	AVERAGE COMPRESSIVE STRENGTH (N/mm^2)		
				7DAYS	14DAYS	28DAYS
1.	8% N	8%N+10%F	83.9	3.54	3.63	3.72
		8%N+20%F	87	3.67	3.76	3.86
		8%N+30%F	93	3.82	3.9	4.03
2.	10%N	10%N+10%F	97.1	4.11	4.21	4.31
		10%N+20%F	99	4.25	4.34	4.4
		10%N+30%F	103	4.37	4.50	4.57
3.	12%N	12%N+10%F	109	4.69	4.79	4.84
		12%N+20%F	112	4.8	4.89	4.97
		12%N+30%F	117.7	5	5.11	5.23

TABLE-5: COMPRESSIVE STRENGTH VALUES IN ACI METHOD

S.No.	NYLON FIBER	MIX	FAILURE LOAD (KN)	AVERAGE COMPRESSIVE STRENGTH (N/mm^2)		
				7DAYS	14DAYS	28DAYS
1.	8% N	8%N+10%F	95	4	4.11	4.22
		8%N+20%F	99.8	4.24	4.32	4.43
		8%N+30%F	104.7	4.49	4.57	4.65
2.	10%N	10%N+10%F	107.9	4.53	4.67	4.79
		10%N+20%F	112.6	4.86	4.92	5
		10%N+30%F	115.5	4.97	5.06	5.13
3.	12%N	12%N+10%F	118.8	5.09	5.18	5.28

		12%N+20%F	122.6	5.24	5.38	5.44
		12%N+30%F	128.5	5.52	5.60	5.71



4.2. SPLIT TENSILE STRENGTH:

A measure of the capacity to oppose a power that tends to pull a section. It is communicated as the base tractable pressure expected to part the material separated. Cylinder specimen of size 150mm diameter and 300mm height is used. The mould was then filled with concrete in three layers and compacted using a tampering rod. Further, the moulds were placed on the vibrating table for 60 seconds to achieve proper compaction and subsequently maintained on a plane and level surface in the laboratory for 24 hours. The cylinders were demoulded and set aside for curing.

Split tensile strength = $^{2P}/_{pi\ DL}$ (N/mm^2)

where, P = Maximum applied load indicated by the testing machine

D = Diameter (mm) = 150mm

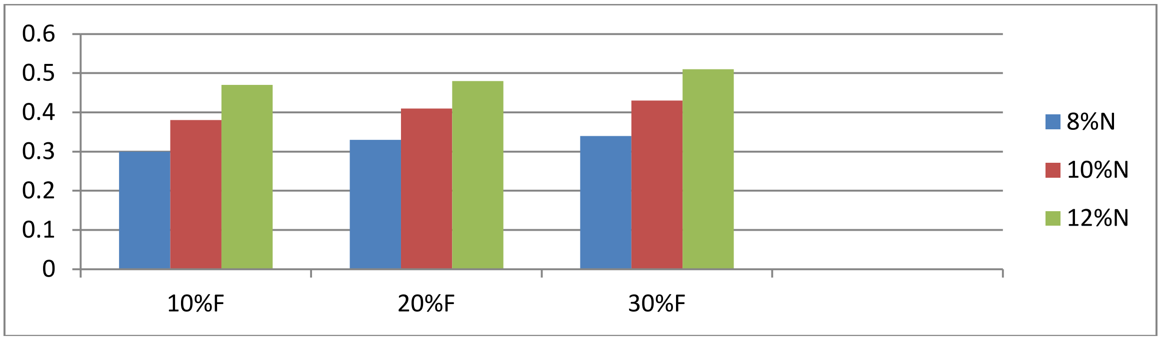
L = Length (mm) = 300mm

TABLE-6: SPLIT TENSILE STRENGTH VALUES IN BIS METHOD

S.No.	NYLON FIBER	MIX	FAILURE LOAD (KN)	AVERAGE SPLIT TENSILE STRENGTH (N/mm^2)		
				7DAYS	14DAYS	28DAYS
1.	8% N	8%N+10%F	192.5	2.63	2.68	2.72
		8%N+20%F	197	2.67	2.75	2.78
		8%N+30%F	199.8	2.71	2.77	2.82
2.	10%N	10%N+10%F	201.9	2.75	2.80	2.85
		10%N+20%F	207.5	2.80	2.87	2.93
		10%N+30%F	210	2.86	2.91	2.97
3.	12%N	12%N+10%F	212.4	2.90	2.95	3
		12%N+20%F	216.9	2.96	3.01	3.06
		12%N+30%F	222	3.02	3.07	3.14

TABLE-7: SPLIT TENSILE STRENGTH VALUES IN ACI METHOD

S.No.	NYLON FIBER	MIX	FAILURE LOAD (KN)	AVERAGE COMPRESSIVE STRENGTH (N/mm^2)		
				7DAYS	14DAYS	28DAYS
1.	8% N	8%N+10%F	213.6	2.91	2.96	3.02
		8%N+20%F	220.2	2.98	3.04	3.11
		8%N+30%F	223.8	3.03	3.10	3.16
2.	10%N	10%N+10%F	228.3	3.11	3.17	3.23
		10%N+20%F	236.5	3.20	3.28	3.34
		10%N+30%F	240.5	3.30	3.35	3.40
3.	12%N	12%N+10%F	245.3	3.32	3.40	3.47
		12%N+20%F	249.6	3.38	3.45	3.54
		12%N+30%F	256.4	3.48	3.52	3.65



Graph on split tensile strength comparision between BIS and ACI method

4.3.FLEXURAL STRENGTH:

The flexural strength is a stress at failure in bending. Flexural strength also known as modulus of rupture or bend strength or transverse rupture is a material property, defined as the stress in material just before it yields flexural test. the relationship between split tensile strength and flexural strength of concrete is calculated as per A comparative analysis of modulus of rupture and splitting tensile strength of recycled aggregate concrete by Akinkurolere Olufunke Olanike, Ekitistate university journal. i.e., ft = 0.63*fck

where, f_t = modulus of rupture

f_{ck} = F/A

F = Maximum applied load indicated by the testing machine

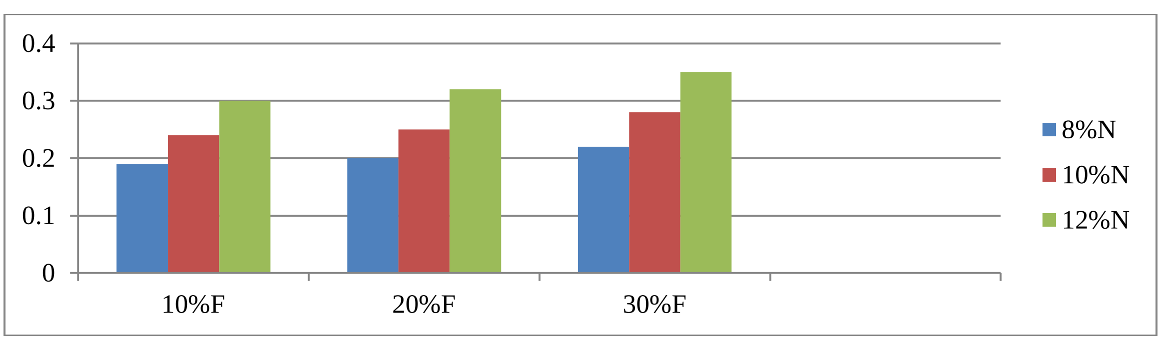
A = Area of specimen

TABLE-8: FLEXURAL STRENGTH VALUES IN BIS METHOD

S.No.	MIX	Average Tensile strength (N/mm^2)		
		7 days	**14 days**	**28 days**
1.	8%N+10%F	1.65	1.68	1.71
2.	8%N+20%F	1.68	1.73	1.75
3.	8%N+30%F	1.70	1.74	1.77
4.	10%N+10%F	1.73	1.76	1.79
5.	10%N+20%F	1.76	1.80	1.84
6.	10%N+30%F	1.80	1.83	1.87
7.	12%N+10%F	1.82	1.85	1.89
8.	12%N+20%F	1.86	1.89	1.92
9.	12%N+30%F	1.90	1.93	1.97

TABLE-9: FLEXURAL STRENGTH VALUES IN ACI METTHOD

S.No.	MIX	Average Tensile strength (N/mm^2)		
		7 days	**14 days**	**28 days**
1.	8%N+10%F	1.83	1.86	1.90
2.	8%N+20%F	1.87	1.91	1.95
3.	8%N+30%F	1.90	1.95	1.99
4.	10%N+10%F	1.95	2	2.03
5.	10%N+20%F	2	2.02	2.09
6.	10%N+30%F	2.02	2.07	2.15
7.	12%N+10%F	2.08	2.11	2.19
8.	12%N+20%F	2.10	2.13	2.24
9.	12%N+30%F	2.15	2.18	2.32



Graph on flexural strength comparision between BIS and ACI method

5. CONCLUSION:-

The following conclusion can be drawn from the results obtained from the experimental investigations.

The specimen cast with 8% nylon fiber replacement by fine aggregate and 10%,20%, and 30% fly ash replacement by cement gives compressive strength of 0.25% increased, split tensile strength of 0.32% increased, and flexural strength of 0.20% increased when compared to BIS method and ACI method.

The specimen cast with 10% nylon fiber replacement by fine aggregate and 10%, 20% and 30% fly ash replacement by cement gives compressive strength of 0.35% increased, split tensile strength of 0.36% increased, and flexural strength of 0.23%increased when compared to BIS method and ACI method.

The specimen cast with 12% nylon fiber replacement by fine aggregate and 10%, 20% and 30% fly ash replacement of cement gives compressive strength of 0.146% increased, split tensile strength of 0.4% increased, and flexural strength of 0.25% increased when compared to BIS method and ACI method.

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