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A STUDY ON STRENGTH CHARACTERISTICS OF CONCRETE BY ADDITION OF NYLON FIBER

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ABSTRACT: Concrete is one of the world most widely used construction material. However, concrete is a brittle material where as steel is a ductile material. Concrete is strong in compression but weak in tension. But, steel is strong in tension and weak in compression. Weak tensile strength combined with brittle behaviour result in sudden tensile failure without warning. Hence, fibers added in concrete improves the tensile strength. Fibers are commercially available and manufactured from steel, plastic, glass, nylon and other natural materials. Fiber reinforced concrete is the concrete containing fibrous materials which increases it's structural resistance, designed strength and it controls cracking. Some types of fibers produce greater impact resistance, high strength properties in concrete and also high chemical resistance, high melting point, corrosion resistance and excellent tensile properties in concrete as it provides Secondary reinforement that is always positioned in compliance with IS standard codes.

For this project, Nylon fiber is selected for study. In this, testing specimens i.e., cubes of size (150×150×150)mm, cylinders of size 150mm(dia)×300mm(depth) and beams of size (500×100×100)mm were casted by the addition of nylon fibers with different percentages of 2%, 4% and 6% by using M30 grade. These specimens are cured in portable water for a period of 28 days. Then further tests are conducted such as Compressive strength, Splitting tensile strength and Flexural strength tests on specimens to study it's structural behaviour.

Keywords : Nylon fiber , Fibre reinforced concrete , Secondary reinforcement , Compressive strength , Splitting tensile strength , Flexural strength.

1. INTRODUCTION

1.1 CONCRETE:

Concrete is a composite material consists of mainly water, coarse aggregate, fine aggregates and cement. The physical properties desired for the finished material can be attained by adding additives and reinforcements to the concrete mixture. A solid mass that can be easily molded into desired shape can be formed by mixing these ingredients in certain proportions. Over the time, a hard matrix formed by cement binds the rest of the ingredients together into a single hard (rigid) durable material with many uses such as buildings, pavements etc., The technology of using concrete was adopted earlier on large-scale by the ancient Romans, and the major part of concrete technology was highly used in the Roman Empire. The colosseum in Rome was built largely of concrete and the dome of the pantheon is the World's largest unreinforced concrete structure. After the collapse of Roman Empire in the mid-18th century, the technology was re-pioneered as the usage of concrete has become rare. Today, the widely used man made material is concrete in terms of tonnage.

1.2 PROPERTIES OF CONCRETE:

Generally, the Concrete is a material having high compressive strength than to tensile strength. As it has lower tensile stress it is generally reinforced with some materials that are strong in tension like steel. The elastic behavior of concrete at low stress levels is relatively constant but at higher stress levels start decreasing as matrix cracking develops. Concrete has a low coefficient of thermal expansion and its maturity leads to shrinkage. Due to the shrinkage and tension, all concrete structures crack to some extent. Concrete prone to creep when it is subjected to long-duration forces. For the applications various tests be performed to ensure the properties of concrete correspond to the specifications. Different strengths of concrete are attained by different mixes of concrete ingredients, which are measured in psi or Mpa. Different strengths of concrete are used for different purposes of constructions. If the concrete must be light weight a very low-strength concrete may be used. The Lightweight concrete is achieved by the addition of lightweight aggregates, air or foam,

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the side effect is that the strength of concrete will get reduced. The concrete with 3000-psi to 4000-psi is often used for routine works. Although the concrete with 5000-psi is more expensive option is commercially available as a more durable one. For larger civil projects the concrete with 5000-psi is often used. The concrete strength above 5000 psi was often used for specific building elements. For example, the high-rise concrete buildings composed of the lower floor columns may use 12,000 psi or more strength concrete, to keep the columns sizes small.

Bridges may use concrete of strength 10,000 psi in long beams to minimize the number of spans required. The other structural needs may occasionally require high strength concrete. The concrete of very high strength may be specified if the structure must be very rigid, even much stronger than required to bear the service loads. For these commercial reasons the concrete of strength as high as 19000-psi has been used.

1.3 USING FIBERS AS CONCRETE ADMIXTURES

Admixtures are the materials other than cement, aggregate and water that are added to concrete either before or during its mixing to alter its properties such as workability, curing temperature range, set time or color. Addition of fiber to concrete 3makes it tough and fatigue resistant such type of admixture is used extensively in important engineering projects. Addition of fiber to concrete is a convenient and practical method of improving several properties of the materials for example toughness, impact resistance and flexural strength. It also assists in changing the flow characteristics of the material. The use of new materials and modern techniques is important in construction activities. Proper use of different kinds of materials and the latest technology becomes imperative to improve quality and cut costs. The life and durability of structure also increases.

1.4 ENVIRONMENTAL BENEFITS OF NYLON FIBER:

The environmental load of fiber-reinforced polymer(FRP) reinforced pavement was compared with that of steel reinforced pavement. Replacing steel rebars with FRP rebars can lead to changes in the concrete mix and pavement structure at the erection stage, to a reduced need for maintenance activities related to steel corrosion, and to different recycling opportunities at the disposal stage. The current study examined all of these variables. The environmental load of Fibre reinforced pavement was found to be significantly lower than that of steel reinforced pavement. This result mainly from the fact that Fiber reinforced pavement requires less maintenance, its cement content and concrete cover over reinforcement can be reduced, and the reinforcement itself generates a smaller environmental load

2. LITERATUREREVIEW

E. Siva Subramanian et al[1] has studied “Experimental Investigation Of Concrete Composite Using Nylon Fiber” and identified that Nylon Fiber Reinforced Concrete has far better strength than normal concrete. He took four mix designs of concrete including Nylon Fiber

Anirudh Swami et al has studied “Use of Nylon Fiber in Concrete” and concluded that nylon fiber is non-environmental friendly so it must be properly disposed off. The fibersimproves its strength, tensile strength, durability. If used in concrete, it decreases the nylon in disposing off making it environmental friendly concrete. The workability of concrete is reduced as nylon absorbs water thus reducing the slump value. It gives best strength when used with 1% of nylon fiber. The tensile strength also increases by 60- 70% at high amount of nylon fiber which makes it useful in places where it is expected that slight tensile stresses may overcome like temperature stresses, creep etc.

Jaya Saxena et al has studied “Enhancement the Strength of Conventional Concrete by using Nylon Fiber” and concluded that nylon fiber mixed with concrete gives better compressive strength. He also tested with 0.2%, 0.25%, 0.3% nylon fiber reinforced concrete and found the strength of concrete increased. He added 10%, 20%, 30% fly ash with concrete having different percentage of nylon fiber as mentioned above and found good strength of concrete.

K.Manikandan et al has studied “Experimental Investigation On Nylon Fiber Reinforced Concrete” and found that 2% nylon fiber replaced with fine aggregate gives improved strength of concrete. The compressive strength is increased by 1.1%, split tensile strength is increased by 1.06% and flexural strength is increased by 1.29%. The specimen was also cast with 4% and 6% nylon fiber and the strength was improved.

Saravana KUMAR Jagannathan et al studied “An Experimental Investigation on Nylon Fiber (Textile Waste) Reinforced Concrete” and concluded that

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addition of fiber 0.5%, 1.0% and 1.5% in concrete and found that the concrete containing 1.0% of fiber has the good strength as compared to others. He also got that there will be reduction in pollution caused due to nylon fiber as it is utilized in concrete.

M. Nazeer et al has studied "Strength Studies on Metakaolin Blended High-Volume Fly Ash Concrete" and concluded that flyash and metakaolin mixed with concrete reduces the workability of concrete. Addition of metakaolin reduces compressive strength, split tensile strength, flexural strength of concrete specimen.

Kamaldeep Kaur et al studied "Determination of Optimum Percentage of Metakaolin by Compressive Strength and XRD Analysis and found that compressive strength is increased on addition of 0%, 7%, 8% but it gets decreased after further addition of metakaolin,

Nova John studied "Strength Properties of Metakaolin Admixed Concrete" and observed that addition of metakaolin increases faster early age strength. 15% replacement of metakaolin with cement gives better strength of concrete.

S.Hemalatha et al. (2016) study experiment weredone with the Cem-FIL Fibre with the length of 12mm, which has resistance with alkali resistant. The fiber was added in concrete with an increment of 0.33% and added up to 2%. In this experiment ConPlast admixture (Super Plasticizer) is used at a rate of 1% to the weight of cement. In this work, M40 grade of concrete is used. The compressive strength of the concrete increases until 1% of glass fiber is added to the concrete after that strength decline gradually. The compressive strength of the concrete increased by (48.88Mpa) 1.22 time of the target means strength of the concrete. M40 Grade of concrete attains a flexural strength of 6.86 Mpa and Tensile strength of 7.96 Mpa when 1% of glass fiber is added to theconcrete.

MATERIALS & PROPERTIES5

S.NO	Properties	Test results	IS: 169-1989
1.	Normal consistency	0.45	
2.	Initial setting time	29min	Minimum of 30min
3.	Final setting time	598min	Maximum of 600min
4.	Specific gravity	3.18	

Table-1 Properties of cement

S. No	Description Test	Result
1	Sand zone	Zone- II
2	Specific gravity	2.63
3	Free Moisture	0.01
4	Fineness modulus	3.19

Table 2: Properties of Fine Aggregate

S. No	Description	Test Results
1	Nominal size used	20mm
2	Specific gravity	2.77
3	Fineness modulus	7.22
4	Water absorption	0.15%

Table 3: Properties of Coarse Aggregate

Properties	Results
Material	100% virgin fiber
Type	Monofilament
Color	White
Fiber length	50 mm
Diameter	0.35 mm
Aspect ratio	142.86
Melt point	435 F (225°C)

Table 4: Properties of NylonFibre

MIX DESIGN FOR M30 GRADECONCRETE:

[According to investigations done on FA, CA, cement]

DESIGN STIPULATIONS DATA:

Gradedesignation : M30
Typeof cement : OPC 53 grade
Maximum nominal sizeofaggregate : 20 mm
Maximumwater-cementratio :0.45
Degreeof supervision : Good
Typeofaggregate :Crushed angular
Exposurecondition :moderate
Workability :100mm(slump)

TEST DATA FORMATERIALS:

1. Typeof cement : OPC 53 grade conforming to IS:
2. Specific gravityofcement: 3.1

3. Specific gravity of

a) Fineaggregates : 2.71

b) Coarseaggregates : 2.78
4. Water absorption of
a) Fineaggregates : 0.34%
b) Coarseaggregates : 0.6%

TARGET MEANSTRENGTH:
[According to IS 10262-2019, clause 4.2]
$f^{l}ck=fck+1.65(S.D)$ $f^{l}ck=35+1.65(5)$
[here S.D is standard deviation from table 2, clause 4.2.1.3]
$f^{l}ck= 43.25N/mm$
Standard Deviation S=5N/mm

SELECTION OF WATER CEMENTRATIO:
[According to IS 456-2000, table 5] (i)
W/C=0.45
(ii) W/C=0.45(from fig 1, IS 10262-2019)
W/C=0.45

SELECTION OF WATERCONTENT:
[According to IS 10262-2019, table 2]
From table 2 of IS 10262:2009, Maximum water = 197.16lit(for 100mm slump) for 20mm aggregate.
Required water content = 197.6liters

CALCULATION OF CEMENT CONTENT:
We have, W/C=0.45
Cement content=197.6/0.45
$=438.13\ kg/m^3$
From table5 of IS 456-2000, the minimum cement content. For moderate exposure condition $=280kg/m^3$
$450kg/m^3 > 320kg/m^3$
Hence ok.

ESTIMATION OF COARSE AGGREGATEPROPORTION:
[According to IS 10262-2009, table 3]
Vol. of coarse aggregate corresponding to 20mm size aggregate and fine aggregate (Zone -2) For water cement ratio 0.50=0.62, But our water content is 0.40 Volume of coarse aggregate is required to be increased to decrease the fine aggregate content, as w/c is lower by 0.10, the proportions of volume of coarse aggregate increased by 0.02.
Volume of coarse aggregate for the water cement ratio=0.64
Volume offineaggregate=0.62-0.01
=0.61

MIXCALCULATIONS:
The mix calculations for unit volume of concrete shall be as follows
Total volume = $1m^3$

vol of cement = (mass of cement/ specific gravity of cement)×(1/1000)
= (438.13/3.18) × (1/1000)
= 0.137 m^3
vol. of water = (mass of water/ specific gravity of water) ×(1/1000)
= (197.16/1) × (1/1000)
=0.197 m^3
Volume of add mixtures = Nill
vol. of all in aggregates = [(a-b)-(c+d)]
= [(1-0.01)-(0.137+0.197)]
=0.656m
mass of CA = 0.656 × (vol. of CA) × (specific gravity of CA) ×1000
= 0.656 × 0.61 × 2.78 × 1000

=1130.24 kg
mass of FA = 0.656 × (vol of FA) × (specific gravity of FA) ×1000
= 0.656 × 0.39 × 2.71 × 1000
= 693.32 kg
Mix proportions fortrail(1m)
Cement = 438.13kg/m Water=197.16lit
Fine aggregate = 693.32kg Coarse aggregate
=1130.24kg Water cement ratio = 0.45

Mix proportions byweight:Design mix of M30

C	FA	CA	W
438.13	693.32	1130.24	197.16
1	1.58	2.54	0.45

EXPERIMENTAL DETAILS
WORKABILITY:
The property of fresh concrete which is indicated by the amount of useful internal work required to fully compact the concrete without bleeding or segregation in the finished product. Workability is one of the physical parameters of concrete which affects the strength and durability as well as the cost of labor and appearance of the finished product. Concrete is said to be workable when it is easily placed and compacted homogeneously i.e. without bleeding or Segregation. Unworkable concrete needs more work or effort to be compacted in place, also honeycombs &/or pockets may also be visible in finished concrete.

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DIFFERENT TEST METHODS FOR WORKABILITYMEASUREMENT:

Depending upon the water cement ratio in the concrete mix, the workability may be determined by the following three methods.

a. SlumpTest
b. Compaction FactorTest
c. Vee-bee consistometertest

TESTS TO BE CONDUCTED:

4.Compressive strength
5.split tensile strength
6.flexural strength.

RESULTS & DISCUSSION

Slump Conetest:

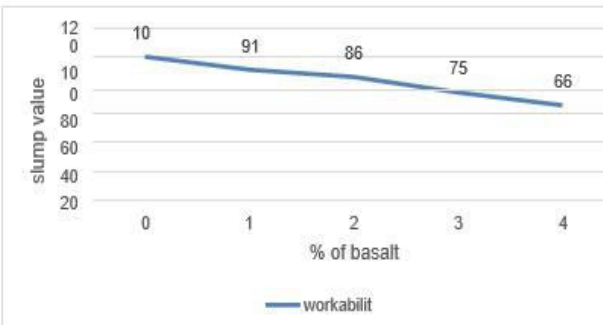

Figure 9: Comparison of workability for different mixes of M30 Grade

From the results it is observed that the workability is decreases with an increase of Glass fiber content over conventional M30 concrete grade.

Compressive strength:

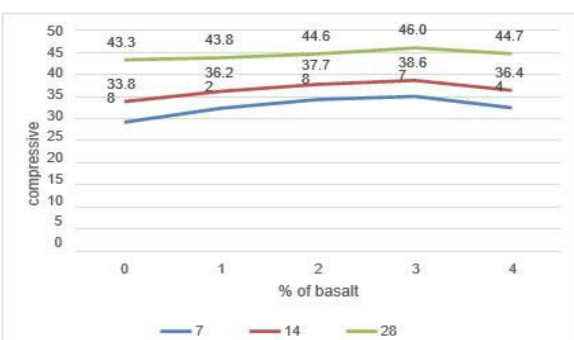

Figure 11: Graph of Compressive Strength comparison at 7, 14 and 28 days for M30 concrete

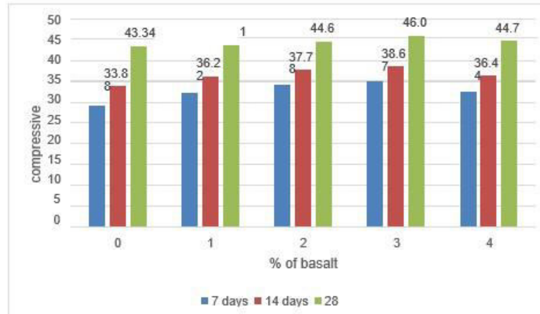

Figure 12: Compressive Strength comparison at 7, 14 and 28 days for M30 concrete

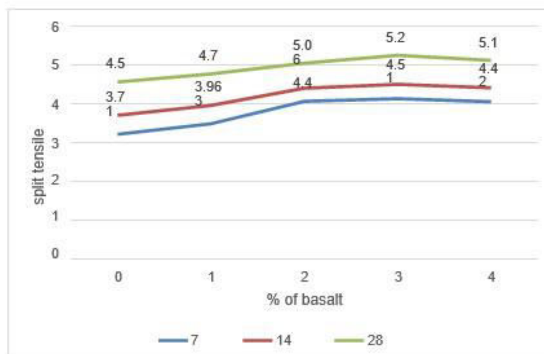

Figure 13: Graph of split tensile Strength comparison at 7, 14 and 28 days for M30 concrete

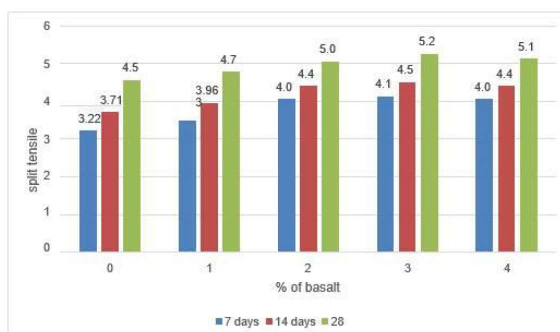

Figure 14: Split tensile Strength comparison at 7, 14 and 28 days for M30 concrete

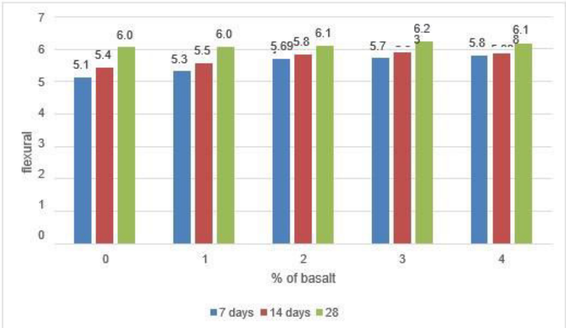

Figure 16: Flexural Strength comparison at 7, 14 and 28 days for M30 concrete

The split tensile strength of concrete varies as 8.5%, 15.9%, 22.6%, 20.6% for M1, M2, M3 and M4 compared with the conventional concrete after 7days of curing.
The split tensile strength of concrete varies as 4.9%, 13.7%, 17%, 16% for M1, M2, M3 and M4 compared with the conventional concrete after 14days of curing.
The split tensile strength of concrete varies as 11.7%, 23.5%, 36.6%, 31% for M1, M2, M3 and M4 compared with the conventional concrete after 28days of curing.

CONCLUSION

From the study, it can be concluded that

a. Nylon fiber concrete increases the compressive strength, flexural strength and tensile strength as compared with the conventionalconcrete.
b. As the percentage of the nylon fiber in concrete increases workability of concrete decreases.
c. From strength point of view, conventional concrete by using nylon fiber shows the positiveresults.
d. It was found from the failure pattern of the specimens, that the formation of cracks is more in the case of concrete without fibers than nylon fiberconcrete.
e. Nylon fiber increases the mechanical properties ofconcrete.
f. It is possible to use nylon fiber in the field of reinforced cement andconcrete.
g. The addition of nylon fiber had a greater compressive and flexural strength at early stages.