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Studies on Mechanical Properties of Concrete Containing Steel Fiber and Post Consumer waste Nylon Fiber

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ABSTRACT: Excluding the waste materials from different sources directly to the environment can actuate environmental issues. Hence reutilization of waste material has been highlighted. Concrete prepared with waste nylon fiber and steel fiber, can enhance the lastingness of reinforced concrete structures and reduce environment pollution. Generation of Nylon from garment interlinings, tooth brush, Fishing lines, Nets and building structures etc, steel from waste steel wire, recycling of waste tyre and rubber is one of the major environmental problem today. Use of nylon and steel as a fiber in concrete provides a durable modification in mechanical properties, making compatible for the manufacturing of concrete. In this investigation "Aspect Ratio" of nylon fibers and steel fibers are same .i.e. 75.Optimum percentage of use of nylon fibers and steel fibers distinctly and combination of both in equal amount and at varying percentage in coalition with super plasticizers for M20 grade of concrete has been evaluated at (0.25%, 0.50%, 1.00% & 1.50%) by weight of cement in three phases. Parameters selected for investigation are compressive strength, flexural strength and split tensile strength after 7 and 28 days and workability.

KEYWORDS: Nylon fiber, Steel fiber, Super Plasticizer, Aspect Ratio, Compressive strength, flexural strength & split tensile strength

I. INTRODUCTION

Plain cement concrete has some weakness such as low tensile strength, limited ductility, little resistance to cracking, high brittleness, poor toughness, and so on that banned its application. The cracking of concrete may be due to economic structural, environmental factors, but most of the cracks are formed due to inherent internal micro cracks and the inherent weakness of the material to resist tensile forces. Drying shrinkage in the concrete may also results in the formation of cracks. To overcome these deficiencies, extra materials are added to improve the performance of concrete. Fiber reinforced concrete provides solutions for these shortcomings. Inclusion of fibers as reinforcement to concrete results as crack arrestor and improves its static and dynamic properties by preventing the propagation of cracks as well as increases tensile strength of concrete.

Fiber reinforced concrete (FRC) is a composite material, which are the combination of cement, sand, coarse aggregate, water and fibers. In this composite material, short discrete fibers are randomly distributed throughout the concrete mass. The detectable efficiency of this composite material is preferential to that of plain concrete and many other construction materials with equal cost. Due to this advantage, the use of FRC has immovably increased during the last two decades and its current field of application includes such as airport and highway pavements, earthquake-resistant and explosive-resistant structures, mine and tunnel linings, hydraulic structures, rock-slope stabilization, etc.

MECHANISM:

The composite will carry increasing loads after the first cracking of the matrix if the pull-out resistance of the fibers at the first crack is greater than the load at first cracking. At the sections which have been cracked, the matrix does not



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resist any tension and the fibers carry the entire load taken by the composite. With continuous increasing load on the composite, the fibers will tend to transfer the additional stress to the matrix through bond stresses. This rise of multiple cracks will develop continue until either fibers fail or the accumulated local debonding will lead to fiber disengagement.

The uniformly distributed fibers aid in controlling the propagation of small cracks present in the concrete composite, first by improving the overall cracking resistance of concrete composite itself, and later by bridging across even smaller cracks formed after the loading on the member, thereby preventing their widening into major cracks Fig.



Fig.1 Failure mechanism and the effect of fibers

II. PROPERTIES OF MATERIALS

CEMENT: The ordinary Portland cement of 43 grade manufactured by the Ultra Tech Cement Ltd. Company is used in the study, which is in accordance with IS 8112-1989. Having design strength for 28 days being a minimum of 43 MPa or 430 kg/cm^2 .

PHYSICAL PROPERTIES OF CEMENT

Properties		Results	
Fineness		6 %	
Specific gravity		3.15	
Standard consistency		29.3 %	
Initial setting time		40 minutes	
Final setting time		250 minuts	
Compressive strength	3 days	26.50n/mm ²	
	7 days	39.32 n/mm^2	
	28 days	53.78 n/mm^2	

COARSE AGGREGATE: Coarse aggregate are defined as aggregates which are retained on 4.75mm I.S. sieve. These aggregates cover major volume of concrete and contribute towards strength of concrete. There are different types of coarse aggregates: crushed gravel or stones, uncrushed gravel or stones & partially crushed gravel or stone. Graded coarse aggregate are used for producing concrete & is described by its nominal size i.e. 20mm, 10mm, 4.75 mm etc. Coarse aggregate used as 70% by weight of 20 mm size & 30 % of 10 mm size of total aggregate may be taken conforming to IS 383:1970 has been used in this study.



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PROPERTIES OF COARSE AGGREGATE

PROPERTIES	RESULT	
Specific Gravity	2.70	
Water Absorption	0.553 %	
Fineness Modulus	6.66	

FINE AGGREGATE: Fine aggregate are defined as aggregates passing through an IS sieve that is less than 4.75mm gauge beyond which they are recognized as coarse aggregate. Fine aggregate works as packing material between the coarse aggregates.

The Locally available Betwa river sand from palar, Utter Pradesh, India, is used as fine aggregate in the concrete design mix.

PROPERTIES	RESULTS OBTAINED	
Specific gravity	2.613	
Water absorption	1.2 %	
Fineness modulus	2.62	
Silt content	5 %	

PROPERTIES OF FINE AGGREGATE

NYLON FIBER: The nylon fibers are used in manufacture of various products like carpet, rope, fish net, tires and other durable materials. The reason for using nylon fiber is that it has good hardness, resilience and durability; is readily available in different colors, can be dyed, resistant to soil and dirt, good abrasion and wearing characteristic, availability in different cross-section

PROPERTIES OF NYLON FIBER

PROPERTIES	RESULTS	
Length (mm)	30.0	
Diameter (mm)	0.40	
Specific gravity	0.7	
Aspect ratio	75	
Density(kg/m ³)	657	



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Fig.2 Nylon fiber

STEEL FIBER: Plain concrete possesses a very low tensile strength, limited ductility and little resistance to cracking. Internal micro cracks are inherently present in the concrete and its poor tensile strength is due to the propagation of such micro cracks, eventually leading to brittle fracture of the concrete. It has been recognized that the addition of small, closely spaced and uniformly dispersed fibers to the concrete would act as crack arrester and would substantially improve its Compressive and flexural strength properties.

PROPERTIES	RESULTS	
Length(mm)	40	
Diameter(mm)	0.50	
Aspect ratio	75	
Specific gravity	5.86	
Density(kg/m ³)	6879	

PROPERTIES OF STEEL FIBERS



SUPER PLASTICIZERS:

Super plasticizer used in this investigation is **BS-17 3P**. Physical Properties of **BS-17 3P** Super plasticizer according to **Build Smart Construction Chemicals Pvt. Ltd.**

- ✓ Appearance- Dark Brown Liquid
- ✓ Density -1.12 (+/- .02)
- ✓ pH Value 7 to 8
- ✓ Solids by weight -44% (+/- 2)
- ✓ Viscosity- B4 Cup @ 30 Celsius 18 (+/- 2)



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WATER: Potable water free from salts, oils, sugar & any other foreign materials is used for casting and curing of concrete. Water plays a vital role in development of strength of concrete, so the quantity and quality of water should be taken care off. Water having pH of 6.0 to 8.0 and not tasting saline and brackish is suitable for use in mixing of concrete. Generally portable water i.e. water not containing any salinity or alkalinity should be used for mixing in concrete.

MIX PROPORTION

IS 10262:2009 is used for perform the mix design. The grade of concrete prepared was M20. The proportion used in the investigation is shown below. It gives the amount of materials used for making $1m^3$ concrete.

Cement (Kg)	Fine aggregate (Kg)	Coarse aggregate (Kg)	Water (Liter)
383.16	578.70	1204.75	191.58
1	1.51	3.144	0.50

MIX PROPORTION DETAILS

III. RESULT AND DISCUSSION

COMPRESSIVE STRENGTH: After placing specimen in the machine load is applied at a rate of around 140 kg/sq cm/min & the load at which concrete cube starts to fail is noted down as the ultimate load that concrete can bear. Then compressive strength is determined by finding the ratio of ultimate load & cross sectional area of specimen.





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COMPRESSIVE STRENGTH FOR VARIOUS MIXES

FLEXURAL STRENGTH: After placing specimen in the machine load is applied at a rate of 180 kg. /min. The load shall be increased until the specimen fails, and the maximum load applied to the specimen during the test shall be recorded.

Calculation: The flexural strength of the specimen shall be expressed as the modulus of rupture f_b , and it have two cases

Case 1: if 'a' is greater than 200 mm for 150 mm specimen, or greater than 133.3 mm for a 100 mm specimen.

$$f_b = \frac{pl}{bd^2}$$

Case 2: if 'a' is less than 200 mm hut greater than 170 mm for 150 mm specimen, or less than 133.3 mm but greater than 110 mm for a 100 mm specimen.

Then
$$f_b = \frac{3pa}{bd^2}$$

Case 3: If 'a' is less than 170 mm for a 150 mm specimen, or less than 110 mm for a 100 mm specimen, the results of the test shall be discarded

where

a = distance between the line of fracture and the nearer support

b = measured width in mm of the specimen,

Then

d = measured depth in mm of the specimen at the point of failure,

l = length in mm of the span on which the specimen was supported,

and p = maximum load in newtons applied to the specimen



FLEXURAL STRENGTH FOR VARIOUS MIXES

SPLIT TENSILE STRENGTH: After placing specimen in the machine load is applied at a rate of rate within the range $1.2 \text{ N/ (mm^2/min)}$ to $2.4 \text{ N/ (mm^2/min)}$ & the load at which concrete cylinder starts to fail is noted down as the ultimate load that concrete can bear. Then split tensile strength is determined by given equation

$$f_{ct} = \frac{2P}{\pi dl}$$



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Where

P = maximum load in Newtons applied to the specimen,

I = length of the specimen (in mm),

d = cross sectional dimension of the specimen (in mm).



Split tensile strength for various mixes



SLUMP VALUE FOR VARIOUS MIXES



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IV. CONCLUSION

- 1. From the test results of compressive strength, split tensile strength and flexural strength, it can be seen that, in the presence of steel fiber there is an increase in compressive strength, split tensile strength and flexural strength. The crack formation is also very small in fiber specimen compared to the non fiber specimens.
- 2. The findings of the above studies indicate that the addition of fibers to concrete improve not only the strength characteristics but also the ductility.
- 3. Fiber addition improves ductility of concrete and its post-cracking load-carrying capacity.
- 4. The most important contribution of fiber reinforcement in concrete is not to strength but to the flexural toughness of the material.
- 5. Plain concrete fails suddenly once the deflection corresponding to the ultimate flexural strength is exceeded, on the other hand, fiber-reinforced concrete continue to sustain considerable loads even at deflections considerably in excess of the fracture deflection of the plain concrete.
- 6. In FRC crack density is increased, but the crack size is decreased.
- 7. In this investigation addition of fibers to plain concrete reduces the workability.

V. FUTURE SCOPE

- 1. In this investigation it is observe that fiber reinforcement has sufficient strength and ductility to be used as a complete replacement to conventional steel bars in some types of structures; foundations, walls, slabs. The technology that is available today has made is possible to consider fiber reinforcement without the use of conventional steel bars in load carrying structures.
- 2. At some place for maintaining light tensile strength; such as, cover plate of tanks, cover plates of sever system etc.

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