Compressive strength of polypropylene fibre reinforced concrete

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ABSTRACT:

Concrete is the most widely used construction material in the world today. High compressive strength of concrete makes it an ideal material for structure. However its tensile strength is not good as its compressive strength.One major drawback of high strength concrete is that it is brittle. The failure will be sudden and catastrophic, particularly in structures, which are subjected to earthquake, blast or suddenly applied loads. An ideal solution to overcome the serious disadvantages of high strength concrete is to add fibres in the concrete to make a ductile material and avoid sudden failures. Incorporation of fibres in concrete has been found to improve several of its properties: tensile strength, cracking resistance, impacts and wears resistance, ductility and fatigue resistance.

Keywords** : **Cement ,Sand, Polypropylene Fibre

INTRODUCTION :

Portland cement concrete is considered to be a relatively brittle material. When subjected to tensile stresses, non-reinforced concrete will crack and fail. Since mid 1800's steel reinforcing has been used to overcome this problem. As a composite system, the reinforcing steel is assumed to carry all tensile loads.

The problem with employing steel in concrete is that over time steel corrodes due to the ingress of chloride ions. In the northeast, where sodium chloride de-icing salts are commonly used and a large amount of coastal area exists, chlorides are readily available for penetration into concrete to promote corrosion, which favours the formation of rust. Rust has a volume between four to ten times the irons, which dissolves to form it. The volume expansion produces large tensile stresses in the concrete, which initiates cracks and results in concrete spalling from the surface. Although some measures are available to reduce corrosion of steel in concrete such as corrosion inhibitive admixtures and coatings, a better and permanent solution may be replace the steel with a reinforcement that is less environmentally sensitive. More recently micro fibres, such as those used in traditional composite materials have been introduced into the concrete mixture to increase its toughness, or ability to resist crack growth. FRC is Portland cement concrete reinforced with more or less randomly distributed fibres. In FRC, thousands of small fibres are dispersed and distributed randomly in the concrete during mixing, and thus improve concrete properties in all directions. Fibres help to improve the post peak ductility performance, pre-crack tensile strength, fatigue strength, impact strength and eliminate temperature and shrinkage cracks.

Several different types of fibres, both manmade and natural, have been incorporated into concrete. Use of natural fibres in concrete precedes the advent of conventional reinforced concrete in historical context. However, the technical aspects of FRC systems remained essentially undeveloped. Since the advent of fibre reinforcing of concrete in the 1940's, a great deal of testing has been conducted on the various fibrous materials to determine the actual characteristics and advantages for each product. Several different types of fibres have been used to reinforce the cement-based matrices. The choice of fibres varies from synthetic organic materials such as polypropylene or carbon, synthetic inorganic such as steel or glass, natural organic such as cellulose or sisal to natural inorganic asbestos. Currently the commercial products are reinforced with steel, glass, polyester and polypropylene fibres. The selection of the type of fibres is guided by the properties of the fibres such as diameter, specific gravity, young's modulus, tensile strength etc and the extent these fibres affect the properties of the cement matrix.

APPLICATIONS OF POLYPROPYLENE FIBRES:-

Polypropylene Fibres can be used in any concrete member some general applications in which fibres are as follows.

- Industrial Flooring.
- Pavements.
- Tilt-up Panels.
- Sloping Slab.
- Structural Concrete.
- Canal Lining.
- Reinforced Concrete.
- Walls.
- Columns, Beams.
- Driveways.
- Water Tanks.
- Composite Decks.
- Thin Sections.
- Terrace Slab.
- Bridge Decks.
- Overlays / Toppings.
- Mass Concrete.
- Shotcrete.
- Base Waterproofing.

PROPERTIES OF POLYPROPYLENE FIBRES:-

The type, geometry', volume fraction and material properties of fibres, the matrix proportion, and the fibre-matrix interfacial bond characteristic influence the properties of fibre concrete in the fresh and hardened states.

1 .BEHAVIOUR IN COMPRESSION:-

The increase in compressive strength due to the addition of fibres is variable ranging from 0 to 20 percent. A noticeable increase in strain at peak load and a significant increase in ductility resulting in substantially higher toughness generally characterize this change. This increased toughness is useful in preventing sudden and explosive failure under static loading and in absorbing energy in dynamic loading.

2. BEHAVIOUR IN FLEXURE:-

A significant difference in the behaviour of plain and fibre reinforced concrete is found in the flexure test. When the fibre concrete beams are loaded in flexure, two stages of behaviour have been generally observed in the load- deflection curve. The behaviour is more or less linear up to the first crack and then the curve is significantly non-linear and reaches its peak at the ultimate strength or at the maximum sustainable static load. Two factors that significantly influence the flexure test are the fibre type and fibre volume. The flexural load-deflection curves for two types of steel (straight and hooked) fibres, and the comparison of load-deflection curves for different volume fractions of fibres. All types of fibres, when added in sufficient volume fractions, increase the first crack and ultimate flexural strengths of concrete. The effect of steel fibres on the ultimate flexural strength is significant and with its better pullout performance. It is especially effective at large deformations, and crack widths. Polymeric fibres, having relatively low modulus of elasticity, slightly reduce the initial stiffness and ultimate strength but their better extensibility results in a appreciable post-peak performance and toughness. Glass and carbon fibres have relatively small diameters; therefore for the same volume fraction, there are a large number of fibres with closer spacing. Hence they are more effective in limiting the size of the cracks and arresting the micro cracks.

3. DIRECT TENSION:-

There is no standard test to determine the stress-strain curve of FRC in direct tension. Various parameters, like the size of the specimen, method of testing, stiffness of the testing machine, gauge length, and the unpredictable cracking pattern, will influence curves and the tensile strength. The strength in direct tension is generally the same as that of plain concrete. However, the toughness of FRC is one of the two orders of magnitude higher due to the large frictional energy developed during fibre pull out.

4. BEHAVIOUR IN SHEAR:-

In normal reinforced concrete design the shear strength of the reinforced concrete section is assumed to be the summation of the concrete contribution (V_C) and shear reinforcement (stirrup) contribution (V_S).The behaviour of plain concrete in shear is very complex. For design purposes, the shear stress at which failure occurs is assumed to be proportional to the square root of the 28 Days compressive strength. In general, if more than 1 % volume of deformed fibers is used, the fibers provide a substantial contribution to shear capacity and should be considered in the design, However data is not currently available to formulate a general procedure because of the variability among fiber types. A fiber volume fraction of less than 1% is not recommended because lower volume fraction could result in possible weak zones where only a few fibers are present.

ADVANTAGES OF F.R.C:-

1) An assurance of minimum quality: - If the material used in making concrete are of a low grade or if the concrete produced in of sub-standard, then even if the same concrete is used, we are assured of a minimum quality which is required for any construction purpose.
2) Reinforcement positioned where it is needed to do the most good:- Extra amount of fibres can be added to any part of the member, when it is found that excess load would be coming on that particular part.
3) As the fibres are uniformly dispersed all over the members, the surface wear characteristics of concrete are considerably improved.
4) FRC products give more resistance to impact from heavy loads.
5) FRC can be pumped and sprayed like ordinary concrete with less tracking, which occurs in these sections of sprayed ordinary concrete.
6) It cracks less extensively in severe fires than ordinary concrete.

DISADVANTAGES OF F.R.C:-

1) Steel fibres, being costlier at present, FRC become very expensive compared to RCC in terms of materials only.
2) The balling phenomenon which is very undesirable.

Table 1 Technical Information of polypropylene fibre

Absorption	Nil
Fibre Length	6.35 mm – 50.8mm
Melt Point	324^0F
Thermal Conductivity	Low
Acid & salt Resistance	High
Specific Gravity	0.91
Young's Modulus	0.5-3.5 KN/mm^2
Alkali Resistance	Alkali proof
Ignition point	1-100^0 F
Electrical Conductivity	Low

EXPERIMENTAL PROGRAMME

Polypropylene Fibre:-

FibremeshInforce™ e^3 (MD) micro-reinforcement system for concrete - 100 percent virgin homo polymer polypropylene Multidimensional Graded Fibrillated fibres containing no reprocessed olefin material and special engineered and manufactured in an ISO 9001 :2000 certified facility, to an optimum gradation, with 25 individual unique fibre designs for use as concrete reinforcement at a minimum of 0.1% by volume. U.L. Classified. Complies with National Building Code and ASTM C-1116, Type III 4.1.3 ASTM C-1018 Performance Level I and residual strength.

MIX DESIGN FOR GRADE M25:-

Mix Design for grade M25 by adding different % of polypropylene fibre. concrete block strength is found out experimentally with different fibre percentage.

Design requirements:-

1. Characteristic concrete strength at 28 days = 25 N/mm^2
2. Maximum size of aggregate = 20mm.
3. Degree of workability = 0.85cf.
4. Type of exposure = mild.
5. Degree of quality control = good.

Data for Materials:-

1. Type of cement = Ordinary Portland Cement (43 grade)
2. Specific gravity of cement = 3.15
3. Specific gravity of fine aggregate = 2.75
4. Specific gravity of coarse aggregate = 2.75
5. Water absorption of C.A. = 1%
6. Water absorption of F.A. = 1.5%
7. Free surface moisture, C.A. = Nil.
8. Free surface moisture, F.A. = 1.26%

Table 2. Mix Proportions :(By Weight)

Water	Cement	Sand	Coarse Aggregate
188.79 kg 0.47	401.68 kg 1	564.14 kg 1.6	1254.37 kg 3.12

RESULT :-Table 3. Test report for concrete compressive strength of cubes

% Fiber	Trail	7 Days		28 Days	
		Comp Load (KN)	Comp Strength (N/mm2)	Comp Load (KN)	Comp Strength (N/mm2)
0.1%	1	640	28.44	920	40.88
	2	680	30.22	970	43.11
	3	630	28.00	930	41.33
0.25%	1	560	24.89	500	22.22
	2	530	23.55	490	21.77
	3	540	24	500	22.22
0.50%	1	500	22.22	670	29.78
	2	520	23.11	630	28.00
	3	540	24.00	580	25.78
1.00%	1	190	8.44	500	22.22
	2	170	7.55	470	20.88
	3	200	8.88	490	21.77

CONCLUSIONS:-

- Adding 0.1 % of polypropylene fibre in design mix M25,the strength increases about 60 %.
- Fine cracks are not observed.
- Thus, we can conclude that fibres are useful to reduce cracks in the concrete.

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