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Enhancement and Feasibility of Concrete for Road Construction

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Abstract
India has progressed at a rapid pace with economic development of infrastructure and today there is an availability of wide variety of modes of transport by land, water and air. For most of population, overall Road Transport is the primary and preferred mode of transport and India's Road Transport system is among the most heavily used transport system in the world. By increasing the productivity and competitiveness, it plays a pivotal role in the economic development of a nation. Roads play a very important part in any nation's infrastructure as well. It consumes large amounts of energy in terms of their construction and maintenance, and the vehicles travel over them. This energy use results in atmospheric emissions, the reduction of a non-renewable resource, and other environmental impacts. A small percentage of reduction of the non-renewable energy use associated with road transport will have significantly positive impact for sustainable development. Now a day, Concrete roads are used widely because of its durability and safety. They are considerably less prone to wear and tear defects like rutting, cracking, stripping, loss of texture, and potholes that can occur with flexible pavement surfaces. This low maintenance requirement is one of the principal advantages of concrete pavements. Normal Concrete starts developing cracks even before loading. These cracks propagate to form potholes on road pavement which not only reduces life of road but also leads to the major causes of accidents. So because of that the another way to solve the problem is fiber reinforcement to improve physio-Mechanical properties of concrete by selecting approximate range and the percentage of fibers which is difficult to select correct volume of fiber for concreting.
This paper gives experimental investigation of steel, polypropylene and synthetic fiber at a glance. After testing the specimens, result analysis and final conclusion are drawn based on which fiber percentage is selected.

Key words: Aspect Ratio, Life of road, potholes, road pavement, synthetic fiber.

Introduction
Roads are the key to the development of an economy. A good road network constitutes the basic infrastructure that accelerates the development process through connectivity and opening up of the backward regions to trade and investment. Roads also play a key role in inter-modal transport development establishing links with airports, railway stations and ports. In addition, they have an important role in promoting national integration, which is particularly important in a large country like India. Since independence, there has been a tremendous increase in the volume of road traffic, both passenger and freight. However, the main road network comprising of national and state highways has not matched this traffic growth. Much of the expansion of the road network has been through building the rural roads to provide connectivity to rural masses, although 50 percent of the villages are still to be connected with all-weather roads. (The main roads have also not kept pace with the traffic demand in terms of their quality).
Despite their importance to the national economy, the road network in India is grossly inadequate in various respects. The existing network is inadequate and is unable to handle high traffic density at many places and has poor riding quality. Road safety is a growing concern in the present day world. Though India's vehicular population is just one percent of that of the world, 6% of the world accidents occur in India. The national highways, comprising 2% of the entire road network in the country, account for nearly 20% of the road accidents. (Source: - Central Institute of Road Transport). Over 1, 25,000 people are killed and more than 5, 00,000 people are injured in the year 2009 in India due to road accidents. Apart from drivers' skills and behavior, lack of knowledge of road safety, general attitude of the road users, quality and adequacy of the roads are the most important contributors to such accidents.
Prior to the National Highways Development Programme

(NHDP) initiated by the NHAI, almost all National Highways and State Highways were 2-lane, undivided roads with uneven surface causing traffic congestion, required more travelling time, unsafe not only during the night time and in the rainy season by also during the day time. These roads required more fuel, more travelling time and they also added to the environmental pollution.

Transport infrastructure is a key element for the economic growth and development and it plays a fundamental role to achieve the objectives to increase growth and jobs. Efficient infrastructure warranting accessibility attracts centers of production and consumption and thus impacts positively on the regional economy. More efficient infrastructures enable a better mobility for people and goods as well as a better connection between regions. Transport infrastructure influences both the economic growth and the social cohesion. A region cannot be competitive without an efficient transport network. An increased mobility demand is also influenced by our ageing society and by the flexible work patterns more and more applied in various sectors. This is bringing more people to the move and is increasing the request for user-friendly mobility systems. Planning, design and construction of infrastructures have remained largely unchanged over the last century; therefore attention has to be put also on the research of new construction materials and processes with the aim to innovate the sector.

Some of the common problems and issues related to roads are:

- Higher construction Cost.
- Uneven surface and poor riding quality.
- Higher fuel cost.
- Delays and loss of time due to traffic congestion.
- Environmental Pollution due to traffic on roads.
- Inadequacy in timely maintenance of roads due to funds constrains.
- Absence of smoothly running traffic.
- Inadequacy of in-built safety measures in the Road Projects during designing, Construction, operation and maintenance.

Roads made of steel reinforced concrete normally suffer from corrosion of the steel by the salt, which results in the failure of those. Constant maintenance and repairing is needed to enhance the life cycle of the concrete roads. There are many ways to minimize the failure of the concrete roads made of steel reinforce concrete. The custom approach is to adhesively bond fiber polymer composites onto the structure. This also helps to increase the toughness and tensile strength and improve the cracking and deformation characteristics of the resultant composite. But this method adds another layer, which is prone to degradation. These fiber polymer composites have been shown to suffer from degradation when exposed to marine environment due to surface blistering. As a result, the adhesive bond strength is reduced, which results in the de-lamination of the composite.

Fiber-Reinforced Concrete (FRC) results from the addition of either short discrete fibers or continuous long fibers to the cement based matrix. Due to the superior performance characteristics its use by the construction industry has significantly increased in the last 5 years. For highway pavement applications, concretes with early strength are attractive for potential use in repair and rehabilitation with a view towards early opening of traffic.

Their main purpose is to increase the energy absorption capacity and toughness of the material, but also increase tensile and flexural strength of concrete. There is considerable improvement in the post-cracking behavior of concretes containing fibers. Compared to plain concrete, fiber reinforced concrete is much tougher and more resistant to impact .It may also contain pozzolona and other admixtures commonly used in conventional concrete. Fibers of various shapes and sizes produced from steel, plastic, glass, and natural materials are being used; however, for most structural and nonstructural purposes, steel fiber is the most commonly used of all the fibers.

For many applications, it is becoming increasingly popular to reinforce the concrete with small, randomly distributed fibers. Concrete containing a hydraulic cement, water, fine or fine and coarse aggregate and discontinuous discrete fibers is called fiber-reinforced concrete (FRC).

Conditions for using fibers in concrete:

Fibers must have a high aspect ratio, i.e. they must be long relative to their diameter. It should be noted that published information tends to deal with high volume concentrations of fiber. However, for economic reasons, the current trend in practice is to minimize fiber volume, in which case improvements in properties maybe marginal. For the quantities of fibers typically used (less than 1% by volume for steel and about 0. 1% by volume for polypropylene) the fibers will not have significant effect on the strength or modulus of elasticity of the composite. It is thus important to evaluate published test data and manufacturer’s claims carefully. It must also be noted that high volume concentrations of certain fibers may make the plastic concrete unworkable.

Types of fibers:

1. Steel fibers
2. Synthetic fibers
3. Polypropylene
4. Acrylic
5. Aramid
6. Carbon
7. Nylon
8. Polyester
9. Polyethylene
10. Glass

Methods

An experimental investigation is to be carried out to know the optimum percentage and type of fiber for concrete pavements.

1.For the Reinforced concrete cube, beam and cylinder be casted with different volume percentage of steel(Fig-1) 1,2,3% polypropylene(Fig-2) 0.2%,0.3%,0.4% and synthetic(Fig-3) 0.2%,0.3%,0.4% fibers in concrete grade of M-40.

2. Total hundred no. of specimens were casted and tested according to the IS codes. Two slabs having dimensions 1m x1m x0.3m have been casted out of which one for normal concrete and the other for 0.3% polypropylene fiber reinforced concrete are casted at the J Kumar RMC plant

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Hadapsar, Pune under the guidance of RMC head Mr. Yusuf Inamdar.

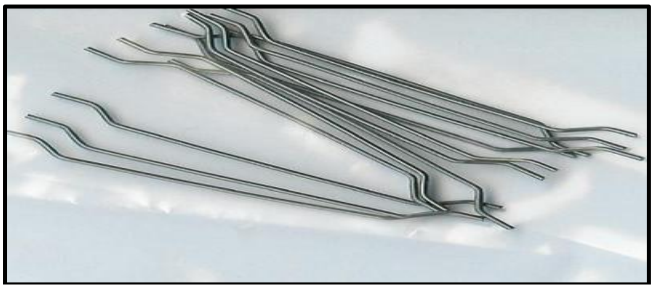


Fig-1 Steel Fibers

Fig-2 Polypropylene Fibers

Fig-3 Synthetic Fibers

Table: 1 Test Results for Fiber

		TEST		
		%Fiber	Comp. Test	Flex. Test
No. Of Sample with Fiber Content	P.C.C	0%	6	4
	S.F	1%	6	4
		2%	6	4
		3%	6	4
	P.P.F	0.2%	6	4
		0.3%	6	4
		0.4%	6	4
	Synthetic	0.2%	6	4
		0.3%	6	4
		0.4%	6	4
	Total	-	60	40

a) Mix design

As per IS10262:2000 the mix design for M40 grade concrete is prepared with varying the percentage of fiber. As use of fibers affects the workability of concrete, the super plasticizer (H.R.Johnson) is used.

Table no: 2 Mix Design given by Sponsor

Sr No	Ingredient	Quantity For 1m^3
1	W/C	0.37
2	Cement	365 kg/m^3
3	Fly ash	85 kg/m^3
4	Crushed sand	826 kg/m^3
5	10 mm aggregate	425 kg/m^3
6	20 mm aggregate	643 kg/m^3
7	Water	165 liter
8	Admixture	4.32 liter

Sources:

Cement- OPC 53grade

Coarse aggregate- VMR, Robo /silicon

Admixture- H.R Johnson (endure-28)

Water- Potable

Fly ash- Nashik

b) Tests on cement

OPC cement of 53 grades is used. The standard consistency of cement is 27%, fineness is 3% and density is 3.12.

c) Tests on aggregates

Table no: 3 Test Results for Aggregates

Sr. No.	Content	10mm	20mm
1	Specific gravity	2.95	2.96
2	Fineness modulus	6.27	7.08
3	Water absorption	0.78%	1.03%
4	Flakiness index	14%	13%
5	Elongation index	18%	18%

d) Tests on water

Table no: 4 Test Results for Water

Sr. No.	Test	Permissible limit
1	Chloride test	10 ppm
2	Sulphite test	5 ppm
3	Hardness	200 ppm

e) Tests conducted on concrete

Specimens of cubes, beams and cylinders are tested after seven and twenty eight days to check compressive, flexural and tensile properties of fiber reinforced concrete for different

percentage of steel and polypropylene fibers. Percentage of fibers used:
Steel fiber: 1%, 2%, 3% of volume of cement and fly ash.
Polypropylene fiber: 0.2%, 0.3%, 0.4% of cement and fly ash.
Syntheticfiber: 0.2%, 0.3%, 0.4% of cement and fly ash.

Fig.4 Flexural Test

Fig.5 Compression Test

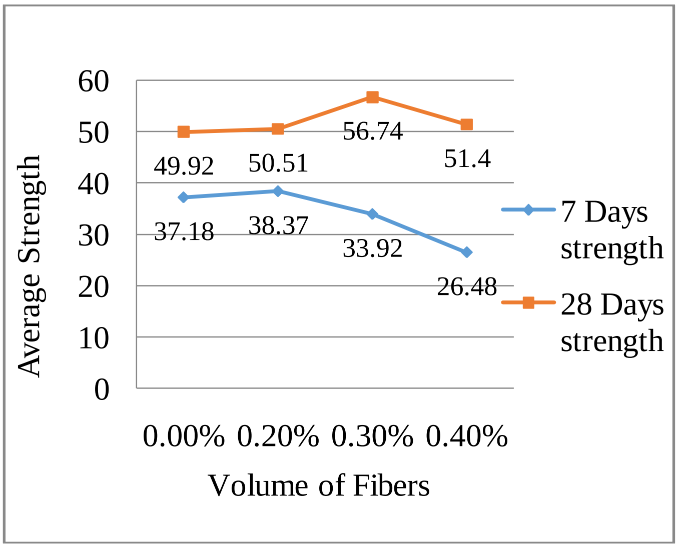
Fig.6 Casting of beams

Results

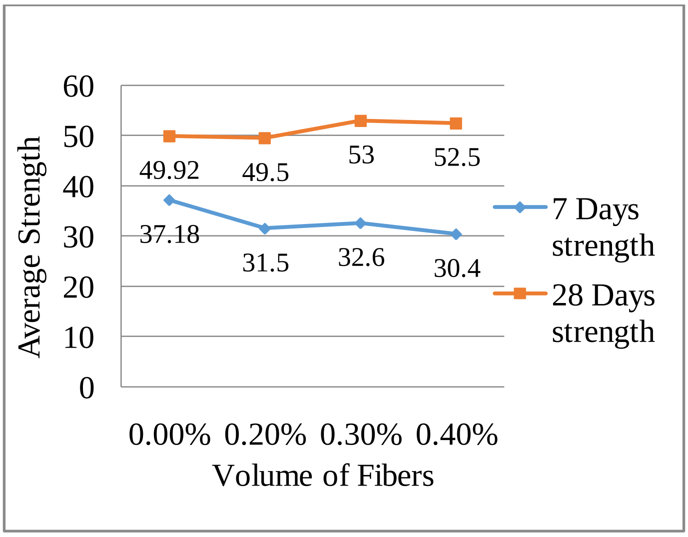
Table no: 5 Results of Compressive Test

Sr.No.	% of Fiber	Type of Fiber & Compressive Strength		% of Fiber	Steel Fiber
		PPF	SY		
1.	0.0	49.42	49.42	0	49.92
2.	0.2	50.51	49.50	1	67.99
3.	0.3	56.74	53.00	2	66.22
4	0.4	51.40	52.50	3	44.74

Graph: 1 Compressive strength analysis of PPF concrete



Graph: 2 Compressive strength analysis of SYF concrete



Graph: 3 Compressive strength analysis of SF concrete

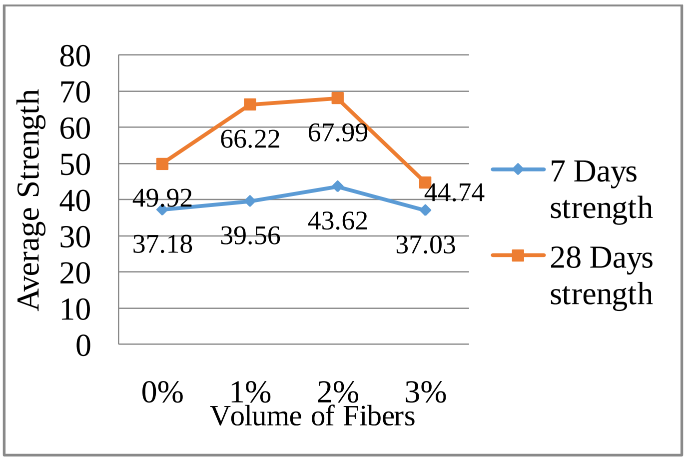
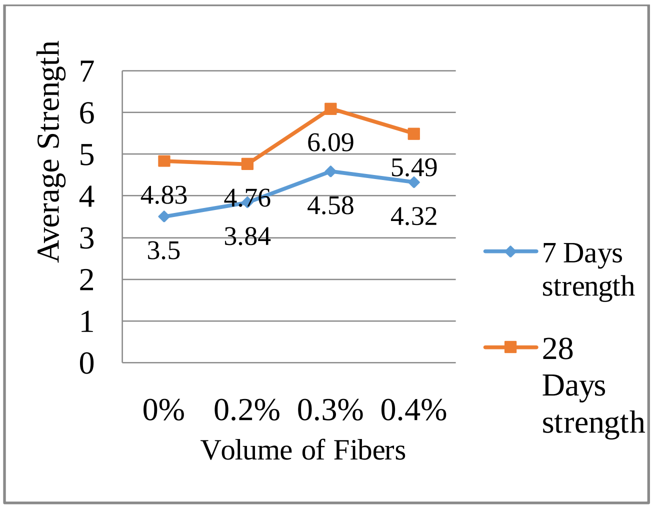


Table: 6 Results of Flexure Test

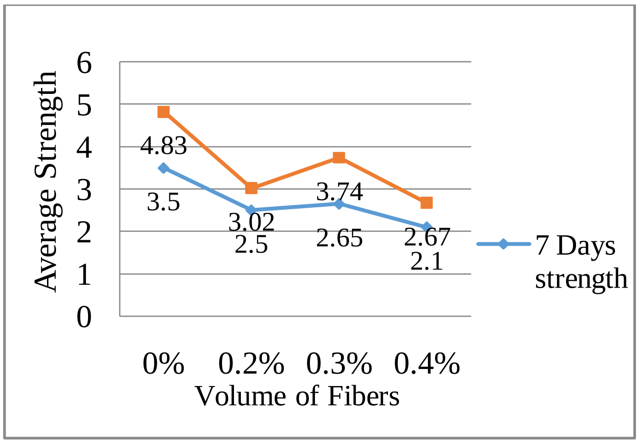
Sr.No.	% of Fiber	Type of Fiber& Flexural Strength		% of Fiber	Steel Fiber SF
		PPF	SYF		
1.	0.0	5.64	5.64	0	5.64
2.	0.2	5.56	3.02	1	5.91
3.	0.3	7.11	3.74	2	6.45
4	0.4	6.41	2.67	3	6.12

Here PPF= Polypropylene Fiber and SYF= Synthetic Fiber, SF= Steel Fiber

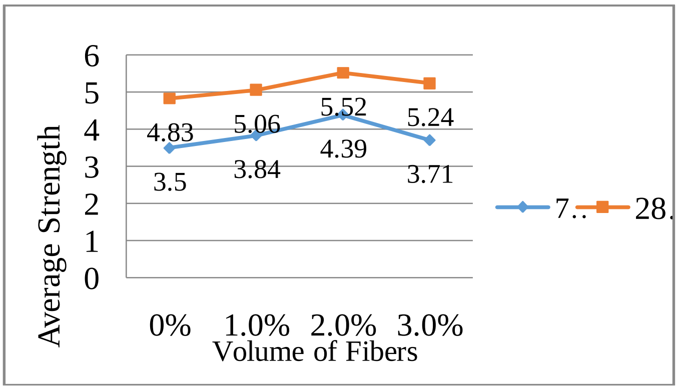
Graph: 4 Flexural strength analysis of PPF concrete



Graph: 5 Flexural strength analysis of SYF concrete



Graph: 6 Flexural strength analysis of SF concrete



Discussion

On the basis of results obtained after testing the samples 0.3% of polypropylene fiber is selected to cast the slab as it gives very good test results for compressive and flexural strength. Basically two slabs normal and fiber reinforced having dimensions 1m x 1m x 0.3m are casted. After curing for 28 days both the slabs are observed.

Fig: 7 Normal Slabs

Fig: 8 FRCSlab (i)

Fig: 9 FRC Slab (ii)

From the above two slab samples it is clear that the crack arresting properties of concrete have significantly increased with the use optimum percentage of fibers to the normal concrete, which indicates the suitability of polypropylene fibers in the concrete pavements.

Conclusion

Polypropylene fiber reinforced concrete

From graph 1, we conclude that that both early flexural strength and maximum flexural strength can be achieved by using 0.3% of polypropylene fibers for 28 days.

Synthetic fiber reinforced concrete

From graph 2, the early compressive strength can be achieved by using 0.0% of polypropylene fibers and maximum tensile strength can be achieved by using 0.3% of polypropylene fibers for 28 days.

Steel Fiber reinforced concrete

From graph 3, the early compressive strength and flexural strength can be achieved by using 2% of steel fibers.

From graph 6, maximum flexural strength and maximum tensile strength can be achieved by using 2% of steel fibers.

With very less increase in cost, Maximum flexural and compressive strength can be achieved by using 0.3% of polypropylene fibers, 2% of steel fibers, and 0.3% of synthetic fibers.
When slabs are casted and cured for 28 days distinguish between the normal concrete and fiber reinforced concrete can be easily studied.

When 0.3% of polypropylene fibers are added in normal concrete the crack arresting phenomenon observed is significantly increased.

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