Diagnosing Performance of Polypropylene Fibre in Concrete Mix Design for Rigid Pavement

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Abstract— *India has a road system of more than 4.87 kilometers according to MoRTH, Techsci Research July 2015 and the second biggest road system on the planet. Development of Road and Highways are the foundation of infrastructure improvement upgrading the vital main thrust to accomplish quick and supported economic growth in the changing technological innovation. It is undoubtedly the lifeline of the nation which is a never ending process activity in India. Because of rising oil costs and a more tightly monetary environment, cement is turning into a more alluring choice for base venture comprehensively contrasted with conventional bituminous asphalts. The Ministry of Road Transport and Highways in India noticed that advanced society can't work adequately without concrete roads. Cement has a few deficiencies as low tensile strength, limited fatigue life and is characterized by brittle failure resulting in nearly complete loss of loading capacity, once failure is initiated. This paper manages exploratory examination on mechanical properties of M35 grade concrete by adding polypropylene fibers in the blend at measurements of 0.6 %, 0.8% and 1.0% by weight of cement added to the mix. A comparative analysis has been carried out for conventional concrete to that of the fiber reinforced in relation to compressive and flexural strengths.*

Keywords — *Polypropylene Fibre, Concrete Mix Design, Compressive Strength, Flexural Strength, Slump test*

I. INTRODUCTION

Transport industry assumes an imperative part in the advancement of financial of a country. Truth be told, the advancement of a country and advancement of its vehicle industry is reciprocal to one another. The road transport industry has a lion's offer in India's financial advancement. Because of simple availability, adaptability of operations, way to entryway administration and dependability, road transport in India demonstrated an increment in offer of both traveler and cargo activity versus different methods of transport. Roads convey right around 85 percent of the nation's traveler movement and 60 percent of its freight with changed vehicle loads on constraining roadway width roads. The main option left to highway engineers is to develop structurally equivalent pavement designs which are durable and economical, as rigid pavement because of hard surface are fuel productive, have great riding strength, increased load carrying capacity and have low maintenance expense contrasted with the flexible pavements is favored. Configuration of concrete pavement begin with the research center tests initiate by finding physical properties of cement, aggregate, sand which must fulfill the necessity according to important is codes. After that conventional concrete mix design test containing admixtures has been completed to focus the compressive strength and flexural strength of bond concrete shape with typical blend at 7 days and 28 days. Correlation between concrete mix with and without polypropylene added in dosages of 0.6 %, 0.8% and1.0 % content in place of cement is worked out to focus the compressive strength and flexural strength which is of most extreme vital to the highway specialists.

II. LITERATURE REVIEW

S.A Kanalli [3] directed a preparatory study on compressive strength, rigidity and flexural utilizing diverse extents of polypropylene fibers brought about a differing proportion of fiber measurements of 0.25 percent by volume of M20 evaluation concrete. Test studies demonstrate that most extreme estimations of compressive split tensile and flexural strength of concrete are acquired at 0.75% fiber measurements.

Rakesh kumar [4] explored suitability of cement reinforced with engineered fiber for the development of pavements. Author quickly talked about the impacts of expansion of polypropylene discrete and fibrillated fiber on the properties of a clearing evaluation concrete mix of 48 Mpa compressive strength at 28-days. Six cement blends were thrown with fiber measurements 0.05%, 0.10% and 0.15%. The properties, for example, settlement, compressive strength, drying shrinkage, and scraped spot resistance of the concrete were assessed.

Rajarajeshwari B Vibhuti [5] considered the impact of expansion of mono fibers and hybrid filaments on the

mechanical properties of cement for pavements. Steel filaments of 1% and polypropylene fibers 0.036% were added exclusively to the concrete mix as mono fibers and after that they were included to shape mixture fiber fortified cement. Mechanical properties, for example, compressive, split pliable and flexural strength were resolved. The outcomes demonstrate that hybrid filaments enhance the compressive strength imperceptibly when contrasted with mono fibers. While, hybridization enhances split tensile strength and flexural perceptibly. She recommended that the enhanced mechanical properties of HFRC would bring about lessening of warping stresses, short and long haul cracking and diminishment of slab thickness.

K. Vamshi Krishna and J. Venkateswara Rao did test examination on mechanical properties of M20 evaluation concrete by joining polyester filaments in the blend. Polyester fibers of 0.1%, 0.2%, 0.3%, and 0.4% by weight of bond are added to the blend. A comparative investigation has been completed for traditional cement to that of the fiber strengthened in connection to compressive, split tensile, flexural strength. As the fiber substance expands compressive, split tensile and flexural strength are relatively expanding. It is watched that 0.3% fibers by weight of cement is the ideal dose. It is found that with 0.3% fiber substance results in 20% lessening of asphalt thickness.

Komal Bedi considered the impacts of polypropylene fiber on the flexure strength of cement. The trial customized was under taken to test standard concrete beam (150 X 150) mm with a span 700 mm for examining strength in flexure. The specimens were contrasted with no fiber and polypropylenes fiber of force 0.89 kg for each cum of cement. To give a premise to flexure, reference examples were thrown without polypropylene fiber. The test outcomes demonstrated that the mechanical properties of flexural strength coming about because of included of polypropylene fiber was generally high.

P. Sathe and, A. V. Patil in their exploration work of trial examination on polypropylene fiber strengthened cement by supplanting river sand to manufactured sand with and without admixture. Utilization of fiber strengthen polymer in structural designing increment quickly. Different kind of fiber is utilized, for example, glass, and carbon, steel, asbestos, polyester and polypropylene. The different trial examinations for determination of properties of polypropylene fiber are talked about in paper work. This paper introduces the impact of polypropylene (PP) fibers on different properties of cement, for example, compressive strength, elasticity, workability, and fracture properties with different substance of fiber (0%, 0.5%, 1.0% , 1.5%). The consequence of this present examination demonstrates that by including of 0.5% of polypropylene fiber indicates greatest compressive and rigidity strength.

III. Experimental Program

The essential properties of material are assessed out for blend outline and are thought seriously about in this paper. The trial modified was under taken to the standard concrete cube of size (150 × 150 × 150) mm for compressive strength of concrete and standard concrete beam of size (150 × 150 × 700) mm for flexural strength of concrete an expect to think about the flexural strength and compressive strength of hardened concrete. Compare about the flexural strength and compressive strength of concrete with and without polyvinyl strands. Concrete mix for M – 35 evaluations was outlined according to IS: 10262-2009.

IV. Materials Used

A. Cement

Ultratech OPC 53 grade cement is used for study purpose as studies revealed that for ordinary Portland cement when water is added to it; the paste is formed, which hardens into rock like mass over a period of time. Compounds like C_3S and C_2S present in cement react in presence of moisture and fully hydrated reaction can be expressed as

$2C_3S + 6H \rightarrow C_3S_2H_3 + 3Ca(OH)_2$
$2C_2S + 4H \rightarrow C_3S_2H_3 + Ca(OH)_2$

Here $C_3S_2H_3$ (Calcium Silicate Hydrate) becomes a hard mass over a period of time and normally called C-S-H gel. 50% of the total heat is liberated between1-3 days and 75% in 7 days, C_3S contributes strength during this period. Nearly 90% of heat is liberated in 28 days, C_2S influences gain of strength generally after 2 weeks. The rate at which the heat is produced is important for practical purposes. The total heat produced, if spread over a longer period (over a year) can be dissipated to a greater degree with fewer problems. During this period the contribution to strength is same for equal individual weight. The hydration of C_3S produces higher heat compared to the hydration of C_2S. Fineness of cement also affects the rate of heat development.
Concrete cubes and beams are casted using it. The basic properties of cement are evaluated in the laboratory to ascertain the strength of cement satisfying relevant codal practice.

TABLE 1
PROPERTIES OF CEMENT

Sr. No.	Characteristics	Result	Limitation as per IS Code	IS Code
1	Fineness	3.21	<10 gm	IS:4031(Part -1) - 1996
2	Normal Consistency	30%	-	IS:4031(Part -4) - 1988
3	Initial Setting Time	80 min	30 min minimum	IS:4031(Part -5) - 1988
4	Final Setting Time	190 min	600 min maximum	IS:4031(Part -5) - 1988
5	Specific Gravity	3.15	-	
6	Compressive Strength at 28 days	54.81 N/mm^2	53 N/mm^2	IS:4031(Part -6) - 1988

B. Fine Aggregate

Part of fine total is to help with creating workability and consistency in blend. It additionally helps the cement paste to hold the coarse aggregate in suspension. The fine aggregate utilized for the exploratory customized was privately obtained and confirmed to Indian standard detail IS: 383 – 1970. The fineness of sand found by sieve investigation represents the extent of sand in concrete and for which zone reviewing of sand is suitable (Refer table-2). The general fineness of sand is given by variable called fineness modulus. Fineness Modulus is given by division of the summation of total retained fractions for standard sieves up to 150-micron sieve size by 100. The fineness modulus of sand varies from 2.0 to 4.0; higher the FM coarser is the sand (Table-3). As the grading zone falls in 2nd, the sand is of coarser category.

Table 3
Properties Of Fine Aggregate

Sr. No.	Characteristics	Result	Limitation as per IS Codes
1	Type	Natural	-
2	Specific Gravity	2.635	-
3	Water Absorption	1.45%	2%
4	Fineness Modulus	3.03	-
5	Grading Zone	Zone-II	-

C. Coarse Aggregate

Aggregates are for the most part considered as inactive filler inside of a concrete blend. Be that as it may, a more critical look uncovers the real part and impact total plays in the properties of both new and hardened concrete. Changes in gradation, greatest size, unit weight, and dampness substance can all modify the character and execution of your concrete mix. Economy is another purpose behind keen aggregate determination. One can regularly spare cash by selecting the most extreme reasonable aggregate size. As in field if perfect gradation does not exist, combined gradation is desirable to be done to better control workability, pumpability, shrinkage and different properties of concrete.

Table 4
Combined Sieve Analysis of Coarse aggregate

I.S.Sieve Size(mm)	% of Passing		% of Mix Proportion		Total % of Passing	Specification limit as per IS 383-1970
	20 mm	10 mm	20 mm 50%	10 mm 50%		
40	100	100	50	50	100	100
20	94.32	100	41.16	50	97.16	95-100
10	5.85	88.52	2.93	44.26	47.19	25-55
4.75	2.64	5.11	1.32	2.89	4.21	0-10

Table 2
Sieve Analysis of Fine Aggregate

I.S.Sieve Size (mm)	Weight Retained (gm)	% retained	Cumulative % Retained	% Passing	Specifiacation of Fine aggregate as per IS-383(% passing)			
					Zone -I	Zone-II	Zone - III	Zone-IV
10	00	00	00	100	100	100	100	100
4.75	85	7.08	7.08	92.92	90-100	90-100	90-100	95-100
2.36	89	7.41	14.49	85.51	60-65	75-100	85-100	95-100
1.18	255	21.25	35.74	64.26	30-70	55-90	75-100	90-100
0.6	230	19.16	54.9	45.1	15-34	35-59	60-79	80-100
0.3	445	37.08	91.98	8.02	5-20	8-30	12-40	15-50
0.15	78	6.5	98.48	1.52	0-10	0-10	0-10	0-15

Table 5
Properties of Coarse Aggregate

Sr. No.	Characteristics	Result	Limitation as per IS Code
1	Type	Crushed Angular aggregate	-
2	Maximum size	20 mm	-
3	Specific Gravity(20 mm)	2.881	-
	10 mm	2.887	
4	Water Absorption (20 mm)	1.33%	<2%
	10 mm	1.38%	
5	Crushing Value	17.38%	<30%
6	Impact value	13.29%	<30%
7	Los Angles Abrasion Test	15.00%	<30%
8	Shape test(Combined Index)	24.69%	<30%

D. Polypropylene Fibre

The raw material of polypropylene is gotten from monomeric C3H6 which is simply hydrocarbon. The specific gravity is 0.91, external appearance of fibers is white, melting point >165 ℃ , diameter of fibers is 30 – 35 microns, tensile strength is 0.67 KN/^{mm2}, young modulus is 4.0 KN/mm^2, absorbency is <0.1 % and fiber cut length is 12mm. Its method of polymerization, its high atomic weight and the way it is handled into fibers concrete to give polypropylene filaments extremely valuable properties as clarified underneath:

• There is a sterically customary nuclear course of action in the polymer atom and high crystallinity. Because of consistent structure, it is known as isotactic polypropylene.

• Chemical inertness makes the filaments impervious to most chemicals. Any compound that won't assault the concrete constituents will have no impact on the fiber either. On contact with more forceful chemicals, the concrete will dependably weaken first.

• The hydrophobic surface not being wet by cement glue keeps chopped fibers from balling impact amid blending like different fibers.

• The water interest is nil for polypropylene filaments.

• The introduction leaves the film feeble in the horizontal direction which encourages fibrillations. The concrete network can in this way enter in the cross section structure between the individual fibrils and make a mechanical bond in the middle of lattice.

E. Admixture

Rheobuild 1126 is dull chestnut colour free flowing liquid made out of manufactured polymers extraordinarily intended to permit impressive decrease of blending water while keeping up control on stretch out of set hindrance as it contains sulphonated naphthalene polymer based definition. It additionally has great scattering strength, high workability for more periods, resistance to segregation even at high workability, extended setting with longer workability, lessened water content for a given workability and increased ease in finishing concrete. It is included 0.9 % by weight of cement in concrete.

F. Water

It is a prevalent view and a measuring yardstick that if water is fit for drinking, it is fit for making concrete. Suitability of water for concrete comparing so as to make is checked after seven days and 28 days strength with cubes 3D shapes made with distilled water. Water containing expansive amounts of chlorides may bring about efflorescence and dampness. We utilize the water having pH esteem value 7.0 and free from salts.

G. Concrete Mix Design M-35grade (IS: 10262-2009)

Table 6
PQC Mix Proportion (dry weight in kg) for Normal Mix

Material	Quantity 1 m^3 (kg)	Quantity 0.027 m^3 (kg) cube
Cement	406	10.962
Coarse Aggregate(20 mm)	618	16.686
Coarse Aggregate (10 mm)	619	16.713
Fine aggregate	754	20.358
Water	154	4.158
Admixture	3.65	98.55

H. Measurement of Workability

Workability: slump test is time honored ritual in concrete technology for knowing the consistency and uniformity of mix. It is dependent on aggregate moisture content, concrete temperature and mixing. One can determine the mixture's vulnerability to segregation when placed. Slump test fulfills the criteria's laid down in MoRTH cl. 602.3.4.2. It is seen that fibers causes obstruction to the free flow of concrete.

Table 7
Result of Slump Test (MoRTH cl. 602.3.4.2)

	Normal Concrete	0.6% polypropylene fibre	0.8% polypropylene fibre	1.0% polypropylene fibre
Required	30 ± 15	30 ± 15	30 ± 15	30 ± 15
Initial	65	57	59	68
After 30 min	45	45	48	54
After 60 min	35	37	40	46
After 90 min	28	30	38	40

I. Compressive Strength

Cement concrete solidifies and picks up strength as it hydrates. The hydration procedure proceeds over a drawn out stretch of time. It happens quickly at first because of C_3S and backs off as time passes by yet proceeds with doe to C_2S. To gauge a definitive strength of cement would require a hold up of quite a while. Literature study reveals that this would be illogical, so a period time of 28 days is chosen by determination composing powers as the age that all concrete ought to be tried. At this age, a significant rate of the hydration has occurred. Compressive strength test demonstrates the load conveying limit by the hardened concrete mix. Subsequently the concrete mixtures can be intended to meet the mechanical and durable properties for the road. Specimens are tried at the ages of 7 and 28 days. To express the compressive strength make normal of qualities of three examples. The individual variety ought not to be more than ± 15 percent of the normal according to codal provision.

Table 8
Compressive Strength of Concrete

Sr. No.	Description	7 days Avg. Compressive Strength of concrete (N/mm^2)	28days Avg. Compressive Strength of concrete (N/mm^2)
1	Normal Concrete Mix Design	49.78	54.81
2	Concrete mix design with 0.6% polypropylene Fibre	51.11	56.59
3	Concrete mix design with 0.8% polypropylene Fibre	46.22	51.11
4	Concrete mix design with 1.0% polypropylene Fibre	45.18	50.22

J. Flexural Strength

Flexural strength is the ability of a beam or slab to resist failure in bending. It is a measure of an unreinforced concrete beam to resist failure in bending. The flexural strength of the specimen is expressed as the modulus of rupture fcr

Let a be the distance between the lines of the tensile side of the specimen. Then, for finding modulus of rupture, there will be two cases should be considered.

CASE (I): When, a > 200 mm for 150 mm specimen

$f_{cr} = P.L / bd^2$

Where,

P = fracture load for beam b = width of the beam

d = depth of the beam. L = span

In my study the First case was found to be suitable.

CASE (II): When, 170 mm < a <200mm for 150 mm specimen $f_{cr} = 3P. a / bd^2$

Table 9
Flexural Strength of Concrete

Sr. No.	Description	7days Avg. Flexural Strength (N/mm^2)	28days Avg. Flexural Strength (N/mm^2)
1	Normal Concrete mix Design	4.53	5.96
2	Concrete mix design with 0.6% polypropylene Fibre	4.80	6.13
3	Concrete mix design with 0.8% polypropylene Fibre	4.44	5.51
4	Concrete mix design with 1.0% polypropylene Fibre	4.26	5.42

V. CONCLUSIONS

PFRC can be used advantageously over normal concrete pavement. Polymeric fibers such as polypropylene are being utilized because of their financially savvy and consumption resistance. This study has been made to focus the impact of polypropylene fibers in suitable measurements on strength of concrete. The research facility examinations gave the accompanying conclusions:

Workability lessens at higher measurements of fibers contrasted with starting dose utilized. The concrete is to be transported from the spot of prepared blend by mobility to the spot of placing the blend for road work; in like manner the slump time should be worked out. Slump worth demonstrates that for control concrete and at 0.6% of fiber substance workability is high and it fulfills the criteria's set down in MoRTH cl. 602.3.4.2.

Up to 0.6% including of concrete with polypropylene fiber 12 mm length there is ideal rate to increment in the improved compressive strength and flexural strength which will allow lessening of slab thickness in wearing surface of cement concrete pavements and because of higher flexural strength prompts less material use. This will further prompt reserve funds in material and work cost by taking out traditional support. A consequence of 0.8% and 1.0% demonstrates that compressive and flexural strength declines.

This demonstrates productive concrete mix design with suitable dose of polypropylene fibers opens another would like to creating and globalizing the strength and reshaping the True's substance "Indian Roads"

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