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Performance of Polypropylene Fibre with Pavement Quality Concrete

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Abstract :-

The effects of Polypropylene fibre in high-strength Pavement Quality Concrete of M40 grade in varied amounts are shown in this article. The goal of this study is to determine the optimal PPF content for improved results and impacts by various content levels such as 0%, 0.30, 0.45, and 0.60 percent. We can also see the impacts of compressive and flexural strength in these studies. We evaluated cube specimens at various ages to see if there was any increase in compressive and flexural strength.

Keywords: Pavement Quality Concrete, Compressive Strength, Flexural Strength, Polypropylene Fibre, M40 Grade.

1. Introduction

Polypropylene fibres have a tendency to reject water and hence do not absorb it. As a result, when placed in a concrete mix, they only need to be mixed for a short time to ensure dispersion. To avoid probable fibre shredding, it's critical to restrict the mixing time to a bare minimum. The collated fibrillated fibre is the type of polypropylene fibre recommended by manufacturers for paving applications. The required fibre length is usually determined by the aggregate content of the combination. Generally. This would be in line with previous steel fibre experiences as well as current ideas on fibre dispersion and bonding." Fiber manufacturers recommend that their product be used in paving for the following purposes: to reduce permeability and plastic shrinkage, cohesiveness, impact resistance, and fatigue (for use in slip forming and on steep inclines), and to provide a cost-effective alternative to welded wire fabric (WWF). They do not, however, propose using fibres to prevent cracking caused by external stresses, boost structural strength, reduce slab thickness, reduce joint spacing, or substitute structural steel reinforcement. These fibres regulate shrinkage at an early age, ensuring that there are no fractures in the pavement's surface. These fibres have no post-crack benefit and are exclusively employed to prevent shrinkage cracking, not to improve other technical features. Most manufacturers recommend 0.1 percent polypropylene fibres by volume of concrete for use in paving combinations and most other mixtures (0.889 to 0.949 kg per cubic meter). Fiber volumes of up to 7.0 percent have been tested by researchers. Continuous fibre is required for uses of greater than 2% fibre volume. Fiber amounts of up to 0.5 percent can be employed without making significant changes to the proportions of the mixture. Air-entraining and water-reducing admixtures are required when using fibre up to 0.5 percent.

Material	**Polypropylene**	**Type**	**Bunchy mono-filament**
Color	White	Identical Diameter(μm)	16/18/25/35/other
Elongation at Break (%)	≥15	Length (mm)	3/6/9/12/15/19/50
Modulus of Elasticity (MPa)	≥3500	Tensile Strength (MPa)	≥450
Density	0.91~0.93	Acid & Alkali	Strong

- ## Role of Polypropylene Fibre in Pavement Quality Concrete

- PP Fibre is a high-intensity bunchy monofilament created of polypropylene by a specific process that successfully prevents concrete microcrack and improves concrete anti-crack, anti-infiltration, anti-concussion, and anti-shock performance. Polypropylene fibres have a tendency to reject water and hence do not absorb it. When it was added to a concrete mix, it spread throughout the mixture. By lowering permeability and shrinking, PPF improves impact resistance, fatigue resistance, abrasion resistance, and cohesion (for use in slip forming and on steep inclines). It also prevents cracking caused by shrinkage and heat pressures in the early stages of a product's life.

- ## Guidelines for PQC in MORT&H & IRC Codes

Fibres may be used subject to the provision in the design/approval by the Engineer to reduce the shrinkage cracking and post-cracking. The fibres may be steel fibre as per IRC:SP:46 or polymeric Synthetic fibres within the following range of specifications:

Effective Diameter	10 micron – 100 micron
Length	6-48 mm
Specific gravity	more than 1.0
Suggested dosage	0.6-2.0 kg/cu.m (0.2 - 0.6% by weight of cement in mix) Usage will be regulated as stipulated in IRC:44/IS:456
Water absorption	less than 0.45 percent
Melting point of this fibre shall not be less than 160°C.	
The aspect ratio generally varies from 200 to 2000.	
These synthetic fibres will have good alkali and UV light resistance.	

When fibres are used, the mix shall be so designed that the slump of concrete at paving site is 25±15 mm.

M-40 (PQC) MIX DESIGN

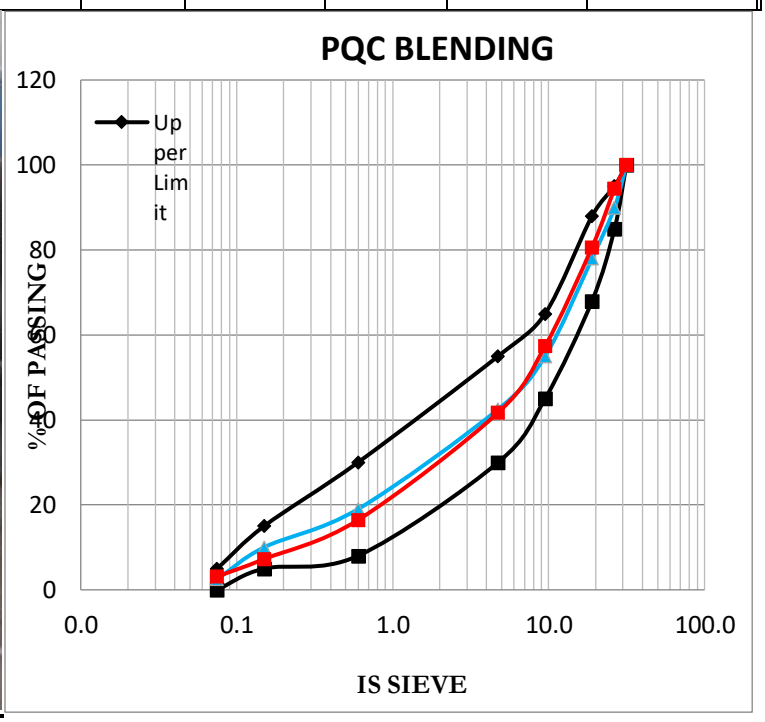
(As Per IS: 10262-2009 & Section-600 of MORTH 5th Rev)

b)	Type of Cement	;	OPC 43 grade conforming to IS: 269
c)	Maximum Size of Aggregate	;	31.5 mm
d)	Characteristics compressive strength	;	40 N/mm^2
e)	Target Compressive Strength	;	52 N/mm^2 (As per MORT&H Table 1700-5)
f)	Characteristics flexural strength	;	4.5 N/mm^2 (As per MORT&H Clause 602.3.3.1)
g)	Target Flexural Strength	;	5.04 N/mm^2 (As per MORT&H Clause 602.3.3.1)
h)	Minimum Cement Content	;	360 kg/m^3 (As per MORT&H Clause 602.3.2)
i)	Maximum Water Cement Ratio	;	0.5 (As per MORT&H Clause 602.3.3.1)
j)	Workability	;	25 ± 15mm (As per MORT&H Clause 602.3.4.2)
k)	Exposure Condition	;	Moderate
l)	Type of Aggregate	;	Crushed Aggregate
m)	Chemical Admixture Type	;	Superplasticizer

- **Tests performed on samples**

Individual Gradation and Blending of Aggregate:-

AGGREGATE BLENDING FOR PAVEMENT QUALITY CONCRETE (PQC)										
	AVERAGE % OF PASSING			MIX PROPORTION			% OF PASING	SPECIFICATION LIMITS		
	30MM	10MM	C.SAND	42.0%	20.0%	38%	100%	MID LIMIT	LOWER LIMIT	UPPER LIMIT
31.5	100	100.00	100.00	42.00	20.00	38.00	**100.00**	100.0	100	100
26.5	86.66	100.00	100.00	36.40	20.00	38.00	**94.40**	90.0	85	95
19.0	53.93	100.00	100.00	22.65	20.00	38.00	**80.65**	78.0	68	88
9.5	1.90	92.91	100.00	0.80	18.58	38.00	**57.38**	55.0	45	65
4.75	0.98	16.57	100.00	0.41	3.31	38.00	**41.72**	42.5	30	55
0.600	0.00	2.45	41.97	0.00	0.49	15.95	**16.44**	19.0	8	30
0.150	0.00	0.00	19.03	0.00	0.00	7.23	**7.23**	10.0	5	15
0.075	0.00	0.00	8.24	0.00	0.00	3.13	**3.13**	2.5	0	5



SUMMARY OF FLAKINESS & ELONGATION INDEX TESTS			
Sample Source	Siddhewadi Stone Quarry	Sample Location	208+900 LHS (DBL Camp)

SR. NO.	SAMPLE-1	SAMPLE-2	SAMPLE-3	Average
1	14.59	15.07	15.65	15.10

SUMMARY OF AGGREGATE IMPACT VALUE TESTS			
Sample Source	Siddhewadi Stone Quarry	Sample Location	208+900 LHS (DBL Camp)

SR. NO.	SAMPLE-1	SAMPLE-2	SAMPLE-3	AVERAGE (%)
1	10.35	11.60	11.55	11.16

SPECIFIC GRAVITY AND WATER ABSORPTION OF COARSE AGGREGATE

(IS : 2386 Part-III)

Sample Source	208+900 LHS (DBL Camp)	Date of Sampling	11-04-2022
Sample Location	Siddhewadi Stone Quarry	Date of Testing	15-04-2022
Proposed use	PQC Mix Design	Type of Material	30 MM

	Test			
	1	**2**	**3**	
Weight of saturated aggregates and Basket in water(W_1) (gm)	1368.4	1452.8	1305.6	
Weight of saturated surface dry aggregates in air(W_2) (gm)	2059	2177	1969	
Weight of oven dried aggregate in air(W_3) (gm)	2038.6	2153.1	1950.3	
Specific Gravity = $W_3/[W_2 - W_1]$	2.952	2.973	2.940	2.955
Apparent Specific Gravity = $W_3/[W_3 - W_1]$	3.042	3.075	3.025	3.047
Water Absorption (%) = 100 x $(W_2 - W_3)/W_3$	1.00	1.11	0.96	1.02

SPECIFIC GRAVITY AND WATER ABSORPTION OF FINE AGGREGATE

(IS : 2386 Part-III)

Sample Location	208+900 LHS (DBL Camp)	Date of Sampling	11-04-2022
Sample Source	Siddhewadi Stone Quarry	Date of Testing	15-04-2022
Proposed use	PQC Mix Design	Type of Material	Crushed Sand

	Trial No			
	1	**2**	**3**	**Average**
Wt of SSD Sample, W1 (gm)	472.0	517.0	495.0	
Wt of Pycnometer Bottle + Water + Sample, W2 (gm)	1806.9	1839.7	1823.0	
Wt of Pycnometer Bottle + Water, W3 (gm)	1496.0	1496.0	1496.0	
Wt of oven dry Sample, W4 (gm)	463.2	507.3	485.8	
Bulk Specific Gravity = W4/[W1 - (W2 - W3)]	2.875	2.927	2.892	2.898
Apparent Specific Gravity = W4/[W4 - (W2 - W3)]	3.041	3.101	3.059	3.067
Water Absorption = 100 x (W1 - W4)/W4	1.90	1.91	1.89	1.90

SPECIFIC GRAVITY OF FLYASH

As Per IS : 2720 (Part -III)

Sample Location	208+900 LHS (DBL Camp)	Date of Sampling	16-04-2022
Sample Source	NTPC Solapur	Date of Testing	16-04-2022
Proposed use	PQC Mix Design	Type of Material	Fly ash

	Trial No			
	1	**2**	**3**	**Average**
Empty wt. of Density Bottle, W1 (gm)	40.77	40.77	40.77	
Wt. of Density Bottle + Half Filled Fly Ash, W2 (gm)	74.41	71.41	72.13	
Wt. of Density Bottle + Half Filled Fly Ash + Kerosene, W3 (gm)	102.55	100.75	101.04	
Wt. of Density Bottle + Full Kerosene, W4 (gm)	81.04	81.04	81.04	
Specific Gravity of Kerosene, W5	0.79	0.79	0.79	
Specific Gravity of Fla Ash = {(W2-W1)/[W4-W1) - (W3 - W2) x W5}	2.19	2.21	2.18	2.20

SPECIFIC GRAVITY OF CEMENT				
Week No.	52	Date of Sampling	18-03-2022	
Source of Cement	Hotgi	Date of Testing	20-03-2022	
Brand of Cement	Ultratech	Grade of Cement	OPC-43 Grade	
Sr. No.	**Description**	**Trial 1**	**Trial 2**	**Trial 3**
1	Sample taken in gms, (W1)	64	64	64
2	Temperature in Centigrade	27	27	27
3	Specific Gravity of Kerosene	0.79	0.79	0.79
4	Initial reading of Le-Chatelier flask	0	0	0
5	Final reading of Le-Chatelier flask	20.4	20	20.3
6	Dispatched Volume, (V)	20.6	20.2	20.3
7	Specific Gravity of Cement, (W1)/V	3.11	3.17	3.15
8	Avg. Specific Gravity of Cement	3.14		

CEMENT CUBE RESULT

Week No.	52	Date of Sampling	18-03-2022
Source of Cement	Hotgi	Date of Casting	20-03-2022
Brand of Cement	Ultratech	Grade of Cement	OPC-43 Grade

Sr. No.	Weight of Cubes (gms)	Density of Cubes (g/cc)	Maximum Load (KN)	Comp. Strength (N/mm^2)	Average Compressive Strength (N/mm^2)
Date: 23/03/2022 (3 Days)					
1	841	2.389	177	35.54	
2	857	2.435	156	31.33	
3	862	2.449	153	30.72	
Date: 27/03/2022 (7 Days)					
4	850	2.415	240	48.19	
5	857	2.435	210	42.17	
6	844	2.398	206	41.37	
Date: 17/04/2022 (28 Days)					
7	851	2.418	294	59.04	
8	860	2.443	276	55.42	
9	846	2.403	282	56.63	

A.) M-40 (PQC) MIX DESIGN With Fly Ash+Polypropylene Fibre

(As Per IS: 10262-2009 & Section-600 of MORTH 5th Rev)

A. Stipulation for proportioning

a)	Grade Designation	;	M-40 (PQC)
b)	Type of Cement	;	OPC 43 grade conforming to IS: 269
c)	Maximum Size of Aggregate	;	31.5 mm
d)	Characteristics compressive strength	;	40 N/mm^2
e)	Target Compressive Strength	;	52 N/mm^2 (As per MORT&H Table 1700-5)
f)	Characteristics flexural strength	;	4.5 N/mm^2 (As per MORT&H Clause 602.3.3.1)
g)	Target Flexural Strength	;	5.04 N/mm^2 (As per MORT&H Clause 602.3.3.1)
h)	Minimum Cement Content	;	360 kg/m^3 (As per MORT&H Clause 602.3.2)
i)	Maximum Water Cement Ratio	;	0.5 (As per MORT&H Clause 602.3.3.1)
j)	Workability	;	25 ± 15mm (As per MORT&H Clause 602.3.4.2)
k)	Exposure Condition	;	Moderate
l)	Type of Aggregate	;	Crushed Aggregate
m)	Admixture Type	;	Superplasticizer + Polypropylene Fibre

B. Test Data for Materials

a) Cement used ; **Ultratech** (OPC 43 grade) conforming to IS: 269

b) Specific Gravity of Cement ; 3.15

c) Chemical Admixture conforming to IS: 9103 ; ***BASF*** *(Master Polyhead 8187)* super plasticizer + **Polypropylene Fibre (PPF)**

d) Specific Gravity of Coarse Aggregate (**Siddhewadi Stone Quarry**)

1) 30 mm Aggregate ; 2.955
2) 10 mm Aggregate ; 2.921

e) a) Specific Gravity of Fine Aggregate (**Siddhewadi Stone Quarry**)

1) Crushed Sand ; 2.898

f) Water Absorption Coarse Aggregate (**Siddhewadi Stone Quarry**)

1) 30 mm Aggregate ; 1.02 %
2) 10 mm Aggregate ; 1.42 %

g) Water Absorption Fine Aggregate (**Siddhewadi Stone Quarry**)

1) Crushed Sand ; 1.90 %

h) Source of Material

1) Coarse Aggregate (30 & 10 mm) ; Siddhewadi Stone Quarry
2) Fine Aggregate ; Siddhewadi Stone Quarry
3) Water ; Siddhewadi Camp Bore Well (208+900 LHS)

B.) M-40 (PQC) MIX DESIGN With GGBS+Polypropylene Fibre

(As Per IS: 10262-2009 & Section-600 of MORTH 5th Rev)

C. Stipulation for proportioning

a) Grade Designation : M-40 (PQC)
b) Type of Cement : OPC 43 grade conforming to IS: 269
c) Maximum Size of Aggregate : 31.5 mm
d) Characteristics compressive strength : 40 N/mm^2
e) Target Compressive Strength : 52 N/mm^2 (As per MORT&H Table 1700-5)
f) Characteristics flexural strength : 4.5 N/mm^2 (As per MORT&H Clause 602.3.3.1)
g) Target Flexural Strength : 5.04 N/mm^2 (As per MORT&H Clause 602.3.3.1)
h) Minimum Cement Content : 360 kg/m^3 (As per MORT&H Clause 602.3.2)
i) Maximum Water Cement Ratio : 0.5 (As per MORT&H Clause 602.3.3.1)
j) Workability : 25 ± 15mm (As per MORT&H Clause 602.3.4.2)
k) Exposure Condition : Moderate
l) Type of Aggregate : Crushed Aggregate
m) Admixture Type : Super plasticizer + Polypropylene Fibre

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D. Test Data for Materials

a) Cement used : **Ultratech** (OPC 43 grade) conforming to IS: 269
b) Specific Gravity of Cement : 3.15
c) GGBS : GGBS conforming to IS :12089
d) Specific Gravity of GGBS : 2.918
e) Chemical Admixture : ***BASF*** *(Master Polyhead 8187)* super plasticizer conforming to IS: 9103
f) Specific Gravity of Coarse Aggregate (**Siddhewadi Stone Quarry**)
   1) 30 mm Aggregate : 2.955
   2) 10 mm Aggregate : 2.921
g) Specific Gravity of Fine Aggregate (**Siddhewadi Stone Quarry**)
   1) Crushed Sand : 2.898
h) Water Absorption Coarse Aggregate (**Siddhewadi Stone Quarry**)
   1) 30 mm Aggregate : 1.02 %
   2) 10 mm Aggregate : 1.42 %
i) Water Absorption Fine Aggregate (**Siddhewadi Stone Quarry**)
   1) Crushed Sand : 1.90
j) Source of Material
   1) Coarse Aggregate (30 & 10 mm) : Siddhewadi Stone Quarry
   2) Fine Aggregate : Siddhewadi Stone Quarry
   3) Water : Siddhewadi Camp Bore Well (208+900 LHS)

2. Future Scope of Study

To study further on this material of Polypropylene Fibre's with Pavement Quality Concrete Compressive strength and Flexural Strength test results and compared with an ordinary mix of Pavement Quality Concrete.

References:-

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2. Guidelines for Pavement Quality Concrete (IRC 44 – 2017).

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