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EFFECT OF MICROSILICA- 600 ON THE PROPERTIES OF WASTE PLASTIC FIBRE REINFORCED (WPFRC) CONCRETE - AN EXPERIMENTAL INVESTIGATION

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Abstract: The main objective of this experimental investigation is to find out the effect of addition of Microsilica in the preparation of waste plastic fibre reinforced concrete and to study the workability and strength characteristics of waste plastic fibre reinforced concrete (WPFRC). The strength characteristics viz., compressive strength, tensile strength, flexural strength, impact strength and workability characteristics are found for WPFRC when Microsilica-600 is added in different percentages viz, 0%, 2%, 4%, 6%, 8%, 10% and 12% respectively by weight of cement. Waste plastic fibres having an aspect ratio 50 (thickness = 1mm, length = 30mm and breadth = 5mm) were added at the rate of 0.5% (by volume fraction). The results show that up to 10% Microsilica-600 can be added by weight of cement into WPFRC, without adversely affecting the compressive strength and with advantage in other strength properties.

Keywords: Fibre reinforced concrete, Waste plastic fibres, Microsilica-600, Strength and workability characteristics

1.0 INTRODUCTION: The fibre reinforced concrete is a composite material consisting of cement paste, mortar or concrete with fibres like asbestos, glass, plastic, carbon or steel. Such fibre reinforced concrete may be useful when a large amount of energy has to be absorbed (Ex: In explosive loading), where high tensile strength and reduced cracking are desirable, or even when conventional reinforcement cannot be placed because of the shape of the member.

However, the addition of fibre in the brittle cement and concrete matrices can offer a convenient, practical and economical method of overcoming their inherent deficiencies of poor tensile and impact strengths, and enhance many of the structural properties of the basic materials such as fracture, toughness, flexural strength and resistance to fatigue, impact, thermal shock and spalling.

The field of concrete technology is advancing at a faster rate. Many inventions in the field of concrete technology have expanded the horizon of the construction industry. These new inventions facilitate to produce the requisite concrete of required nature and property. Many wastes, which are producing environmental pollution, are also finding an effective place in the preparation of concrete. Thus, by using these wastes, which are causing environmental pollution one, can produce concrete that is having the desirable properties.

One such waste, which is causing the environmental pollution, is the plastic. The plastic is a non-biodegradable/non-perishable material. The plastics will neither decay nor degenerate either in water or in soil. In turn it pollutes the water and soil. The plastic if burnt releases many toxic gases, which are very dangerous for the health. Such plastic can be used in concrete in the form of fibres to impart some additional desirable qualities to the concrete.

Another environmental pollutant viz. Silica fume is an amorphous powder which when added with OPC increases the strength and durability of concrete. It also reduces the permeability of concrete and improves the abrasion and erosion resistance.

2.0 MATERIALS USED

Cement: Ordinary Portland Cement-53 grade was used having a specific gravity of 3.15 and it satisfies the requirements of IS: 12269-1987 specifications. The physical properties of tested cement are given in Table 2.1

Table 2.1: Physical properties Ordinary Portland Cement-53 grade (IS: 12269-1987)

Properties	Results	Permissible limit as per IS: 12269-1987
Fineness	30.3 m^2/N	Should not be more than 22.5 m^2/N
Normal consistency	30	-
Specific gravity	3.15	-
Setting Time a. Initial b. Final	 115 Min. 270 Min.	 Should not be less than 30 Min Should not be more than 600 Min
Soundness test a. Le-chat expansion b. Auto clave%	 1 0.09	 10mm maximum 0.8% maximum
Compressive strength of mortar cubes for a. 3days. b. 7days. c. 28 days	 35.5 N/mm^2 47.0 N/mm^2 55.6 N/mm^2	 Should not be less than 27 N/mm^2 Should not be less than 37 N/mm^2 Should not be less than 53 N/mm^2

Coarse aggregates: The crushed stone aggregate were collected from the local quarry. The coarse aggregates used in the experimentation were 10mm and down size aggregate and tested as per IS: 383-1970 and 2386-1963 (I, II and III) specifications. The aggregates used were having fineness modulus 1.9. Sieve analyses of coarse aggregate are given in Table.2.2 and physical and mechanical properties of tested coarse aggregates are given in Table 2.3

Table2.2: Sieve analysis of coarse aggregate (IS: 383-1970)

IS sieve size	Weight retained (grams)	Cumulative weight retained (grams)	Cumulative % weight retained	Cumulative % passing	ISI permissible limit
12.5mm	0	0	0	100	100
10mm	0	0	0	100	85-100
4.75mm	1860	1860	93	7	0-20
2.36mm	93	1953	97.65	2.35	0-5
pan	47	2000	-	-	-
Total	2000	-	190.65	-	-

Fineness modulus = 190.65/100 = 1.90

Table2.3: Physical and mechanical properties of coarse aggregate (IS: 2386-1963)

Properties	Results	Permissible limit as per IS: 2386-1963
Impact value	15.50 %	Should not be more than 30% used for concrete
Crushing value	25%	Should not be more than 30% for surface course and 45% other than wearing course
Specific gravity	2.65	In between range 2.6-2.8
Moisture content	0.16%	-

Fine aggregates: Locally available sand collected from the bed of river Bhadra was used as fine aggregate. The sand used was having fineness modulus 2.96 and confirmed to grading zone-III as per IS: 383-1970 specification. Sieve analysis of fine aggregate are given in Table 2.4 and physical properties tested for fine aggregate are given in Table 2.5

Table 2.4: Sieve analysis of fine aggregate (IS: 383-1970)

IS sieve size	Weight retained (grams)	Cumulative weight retained (grams)	Cumulative % weight retained	Cumulative % passing	Grading zone III
10	0	0	0	100	100
4.75	5	1	99	-	90-100
2.36	44	45	09	91	85-100
1.18	30	75	15	85	75-100
600μm	50	125	25	75	60-79
300μm	185	310	62	38	12-40
150μm	120	430	86	14	0-10
Pan	70	500	-	-	-
Total	500 gm	-	296	-	-

Fineness Modulus: 296/ 100 = 2.96

Table 2.5: Physical properties of fine aggregate (IS: 2386-1963)

Properties	Results	Permissible limit as per IS: 2386-1963
Organic impurities	Colourless	Colour less /Straw Colour/Dark Colour
Silt content	0.7%	Should not be more than 6-10%
Specific gravity	2.63	Should be between the limit 2.6-2.7
Bulking of sand	16%	Should not be more than 40%
Moisture content	0.65%	-

Microsilica: Microsilica-600 used in the experiment complies in all respects to NZS 3122:1995 - Specification for Portland and Blended Cements. The Microsilica-600 used in the experimentation was obtained from Bombay. Properties silica fume are given in Table 2.6

Table 2.6: Chemical and physical properties of Microsilica-600

Chemical analysis		**Particle size analysis**	
SiO_2	87.89	100	100
Al_2O_3	4.31	50	99.6
SO_3	0.13	20	97.9
Fe_2O_3	0.59	10	94.5
MnO	0.03	5	84.6
Tio_2	1.16	2	55.6
CaO	0.32	1	35
K_2O	0.49	0.4	12.2
P_2O_2	0.05		
MgO	< 0.02		
Na_2O	0.14		
LOI	5.01		

* Data taken from the product brochure of the supplier

Fibres: The waste plastic fibres were obtained by cutting waste plastic pots, buckets, cans, drums and utensils. The waste plastic fibres obtained were all recycled plastics. The fibres were cut from steel wire cutter and it is labour oriented. The thickness of waste plastic fibres was 1mm and its breadth was kept 5mm and these fibres were straight. The different volume fraction of fibres and suitable aspect ratio were selected and used in this investigation. Physical properties of these fibres are given in Table 2.7

Table 2.7: Physical properties of waste plastic fibres

Length (l) mm	**Breadth (b) mm**	**Thickness (t) mm**	**Percentage of elongation**	**Tensile strength (MPa)**	**Modulus elasticity (MPa)**	**Water absorption**	**Specific gravity**
150	25	1	15.56	15.52	113.90	Nil	1.28

Water: Ordinary potable water free from organic content, turbidity and salts was used for mixing and for curing throughout the investigation.

Plasticizer: To impart the additional desired properties, a plasticizer (Conplast P-211) was used. The dosage of plasticizer adopted in the investigation was 0.5% (by weight of cement).

3.0 EXPERIMENTAL PROCEDURE: Concrete was prepared by a mix proportion of 1: 1.435: 2.46 with a W/C ratio of 0.48 which correspond to M20 grade of concrete. The different percentage addition of Microsilica adopted in the experimental programme are 0%, 2%, 4%, 6%, 8%, 10% and 12% respectively. Waste plastic fibres having an aspect ratio 50 (thickness = 1mm, length = 30mm and breadth = 5mm) were added in the dry mix at the rate of 0.5% (by volume fraction). All the specimens were cast and tested after 28 days of curing as per IS specifications

The concrete ingredients viz., cement, sand and aggregate were weighed according to the proportion 1: 1.435: 2.46 with a W/C ratio of 0.48 which correspond to M20 grade of concrete and were mixed on a non-absorbent platform in dry condition. The calculated quantity of Microsilica-600 was added. The different percentages of Microsilica-600 used were 0%, 2%, 4%, 6%, 8%, 10% and 12%. Now the waste plastic fibres (0.5% by volume fraction) were added in to the dry mix and re-mixed uniformly. To this dry mix, the calculated quantity of water was added and the concrete was homogeneously mixed. At this stage the calculated quantity of plasticizer was added and is mixed thoroughly. This concrete was placed in the moulds layer by layer and sufficient compaction was given both through hand and vibrator. After vibration they are smooth finished. After 24 hours the specimens were demouled and transferred to the curing tank where in they were allowed to cure for 28 days. After 28 days of water curing the specimens were weighed for their density and tested for their strength. When the mix was wet the workability test like slump test, compaction factor test and flow tests were carried out.

The different strength parameters of waste plastic fibre reinforced concrete like compressive strength, tensile strength, flexural strength and impact strength were found for different percentage addition/replacement of cement by Micro silica-600 as the case may be. The compressive strength tests were conducted as per IS: 516-1959 on specimens of size 150 x 150 x 150 mm. The tensile strength tests were conducted as per IS: 5816-1999 on specimens of diameter 150 mm and length 300mm. Indirect tension test (Brazilian test) was conducted on tensile strength test specimens. Flexural strength tests were conducted as per IS: 516-1959 on specimens of size 100 x 100 x 500mm.Two point loading was adopted on a span of 400 mm, while conducting the flexural strength test. The impact strength tests were conducted as per ACI committee-544 on the panels of size 250 x 250 x 30 mm. A mild steel ball weighing 1.216 kg was droped from a height of one meter on the impact specimen, which was kept on the floor. The care was taken to see that the ball was droped at the center point of specimen every time. The number of blows required to cause first crack and final failure were noted. From these numbers of blows, the impact energy was calculated as follows.

Impact energy = mghN
= w/g x g x h x N
= whN (N-m)

Where, m = mass of the ball
w = weight of the ball =1.216 kg
g = acceleration due to gravity
h = height of the drop =1m
N = average number of blows to cause the failure.

4.0 EXPERIMENTAL RESULTS: The following tables give the details of the experimental results of waste plastic fibre reinforced concrete with different percentage addition of Microsilica.

4.1 Compressive strength test results: The following Table No 4.1 gives the compressive strength test results of waste plastic fibre reinforced concrete with different percentage addition of Microsilica

Table 4.1: Compressive strength test results of waste plastic fibre reinforced concrete with different percentage addition of Microsilica

Percentage addition of Microsilica	Specimen identification	Weight of specimen (N)	Density (kN/m^3)	Average density (kN/m^3)	Failure load (kN)	Compressive strength (MPa)	Average compressive strength (MPa)	Percentage increase or decrease of compressive strength w. r. t reference mix
0 (Ref mix)	A	76	22.52	22.52	640	28.44	28.74	---
	A	76	22.52		640	28.44		
	A	76	22.52		660	29.33		
2	B	74	21.93	21.93	800	35.55	35.4	+ 23
	B	74	21.93		800	35.55		
	B	74	21.93		790	35.11		
4	C	75	22.22	22.22	820	36.44	35.7	+ 24
	C	75	22.22		800	35.55		
	C	75	22.22		790	35.11		
6	D	74	21.93	21.93	900	40	37.03	+ 29
	D	74	21.93		750	33.33		
	D	74	21.93		850	37.77		
8	E	74	21.93	21.93	860	38.22	40.59	+ 41
	E	74	21.93		980	43.55		
	E	74	21.93		900	40		
10	F	74	21.93	22.22	1005	44.66	44.51	+ 57
	F	75	22.23		1000	44.44		
	F	76	22.52		1000	44.44		
12	G	72	21.33	21.53	850	37.77	39.7	+ 38
	G	73	21.63		930	41.33		
	G	73	21.63		900	40		

4.2 Tensile strength test results: The following Table No 4.2 gives the tensile strength test results of waste plastic fibre reinforced concrete with different percentage addition of Microsilica

Table 4.2: Tensile strength test results of waste plastic fibre reinforced concrete with different percentage addition of Microsilica

Percentage addition of Microsilica	Specimen identification	Failure load (kN)	Tensile strength (MPa)	Average tensile strength (MPa)	Percentage increase or decrease of tensile strength w. r. t reference mix
0 (Ref mix)	A	240	3.39	3.81	---
	A	280	3.96		
	A	290	4.1		
2	B	280	3.96	3.86	+ 1
	B	270	3.81		
	B	270	3.81		
4	C	290	4.1	4.05	+ 6
	C	290	4.1		
	C	280	3.96		

6	D	300	4.24	4.24	+ 11
	D	310	4.38		
	D	290	4.1		
8	E	320	4.52	4.52	+ 19
	E	330	4.66		
	E	310	4.38		
10	F	330	4.66	4.81	+ 26
	F	340	4.81		
	F	350	4.95		
12	G	300	4.24	4.24	+ 11
	G	290	4.1		
	G	310	4.38		

4.3 Flexural strength test results: The following Table No 4.3 gives the flexural strength test results of waste plastic fibre reinforced concrete with different percentage addition of Microsilica

Table 4.3: Flexural strength test results of waste plastic fibre reinforced concrete with different percentage addition of Microsilica

Percentage addition of Microsilica	Specimen identification	Failure load (kN)	Flexural strength (MPa)	Average flexural strength (MPa)	Percentage increase or decrease of flexural strength w. r. t reference mix
0 (Ref mix)	A	13.8	5.52	5.53	---
	A	13.8	5.52		
	A	13.9	5.56		
2	B	13.9	5.56	5.58	+ 1
	B	14	5.6		
	B	14	5.6		
4	C	14.2	5.68	5.66	+ 2
	C	14.3	5.72		
	C	14	5.6		
6	D	14.1	5.64	5.7	+ 3
	D	14.3	5.72		
	D	14.4	5.76		
8	E	14.4	5.76	5.77	+ 4
	E	14.5	5.8		
	E	14.4	5.76		
10	F	14.8	5.92	5.88	+ 6
	F	14.7	5.88		
	F	14.6	5.84		
12	G	14.5	5.8	5.7	+ 3
	G	14	5.6		
	G	14.3	5.72		

4.4 Impact strength test results: The following Table No 4.4 gives the impact strength test results of waste plastic fibre reinforced concrete with different percentage addition of Microsilica

Table 4.4: Impact strength test results of waste plastic reinforced concrete with different percentage addition of Microsilica

Percentage addition of Microsilica	Specimen identification	Number of blows required to cause	Average number of blows required to cause	Impact strength (N-m) required to cause	Percentage increase or decrease of impact strength w. r. t reference mix

		first crack	final failure	first crack	Final failure	first crack	final failure	first crack	final failure
0 (Ref mix)	A	6	20	4.34	19.34	52.77	235.17	---	---
	A	4	21						
	A	3	17						
2	B	4	22	4.67	22.67	56.78	275.66	+ 8	+ 17
	B	4	22						
	B	6	24						
4	C	4	22	5	23.34	60.8	283.81	+ 15	+ 21
	C	5	24						
	C	6	24						
6	D	6	24	6.67	24.67	81.1	299.98	+ 54	+ 28
	D	8	24						
	D	6	26						
8	E	9	25	8.67	26.67	105.54	324.3	+ 100	+ 38
	E	6	27						
	E	11	28						
10	F	12	30	10.34	30.67	125.73	372.94	+ 138	+ 59
	F	10	29						
	F	09	33						
12	G	6	25	7	27	85.12	328.32	+ 62	+ 40
	G	6	26						
	G	9	30						

4.5 Workability test results: The following Table No 4.5 gives the overall results of workability of waste plastic fibre reinforced concrete with different percentage addition of Microsilica

Table 4.5: Workability test results of waste plastic reinforced concrete with different percentage addition of Microsilica

Percentage addition of Microsilica	Workability through		
	Slump (mm)	Compaction factor	Percentage flow
0 (Ref mix)	0	0.8	7.5
2	0	0.84	9
4	0	0.84	12.3
6	0	0.85	13.3
8	0	0.86	14.2
10	0	0.86	16.25
12	0	0.84	13

5.0 OBSERVATIONS AND DISCUSSIONS

Based on the experimental results the following observations were made

1. It has been observed that the waste plastic fibre reinforced concrete show an increasing trend in the compressive strength upto 10% addition of Microsilica into it. After 10% addition of Microsilica the compressive strength starts decreasing. Thus, the waste plastic fibre reinforced concrete shows a higher compressive strength when 10% Microsilica is added and the percentage increase in the compressive strength is 55%

   It has been observed that the waste plastic fibre reinforced concrete show an increasing trend in the tensile strength upto 10% addition of Microsilica into it. After 10% addition of Microsilica the tensile strength starts decreasing. Thus, the waste plastic fibre reinforced concrete shows a higher tensile strength when 10% Microsilica is added and the percentage increase in the tensile strength is 26%

   It has been observed that the waste plastic fibre reinforced concrete show an increasing trend in the flexural strength upto 10% addition of Microsilica into it. After 10% addition of Microsilica the flexural strength starts decreasing. Thus, the waste plastic fibre reinforced concrete shows a higher flexural strength when 10% Microsilica is added and the percentage increase in the flexural strength is 6%

It has been observed that the waste plastic fibre reinforced concrete show an increasing trend in the impact strength upto 10% addition of Microsilica into it. After 10% addition of Microsilica the impact strength starts decreasing. Thus, the waste plastic fibre reinforced concrete shows higher impact strength when 10% Microsilica is added and the percentage increase in the impact strength for first crack is 138% and for final failure is 59% respectively.

This may be due to the fact that 10% addition of Microsilica may induce maximum workability through which a thorough compaction can be achieved which aids in higher strengths. Also it may be due to the fact that 10% addition Microsilica may fill all the cavities and induce right pozzolonic reaction.

Thus it can be concluded that 10% Microsilica addition will induce higher strength properties to waste plastic fibre reinforced concrete.

2. It has been observed that the maximum workability is achieved when 10% of Microsilica is added. After 10% addition of Microsilica the workability decreases. The concrete becomes stiff as the percentage of Microsilica increases beyond 10%.

   This may be due to the fact that 10% addition of Microsilica may act as ball bearings thus reducing the friction and enhancing the workability.

   Thus it can be concluded that 10% addition of Microsilica yield good workability in waste plastic fibre reinforced concrete.

6.0 CONCLUSIONS

1. It can be concluded that 10% addition of Microsilica will induce higher strength properties and good workability properties to waste plastic fibre reinforced concrete.
2. Thus Microsilica can be used in the production of waste plastic fibre reinforced concrete

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