EFFECT OF DIFFERENT ASPECT RATIO OF WASTE PLASTIC FIBRES ON THE PROPERTIES OF FIBRE REINFORCED CONCRETE-AN EXPERIMENTAL INVESTIGATION

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Abstract: *The inherent weakness of concrete is its less tensile strength. To improve this inherent weakness many techniques came into picture. Among them one of the best techniques is to introduce the fibres in the concrete mass. Thus fibre reinforced concrete (FRC) is a concrete in which the fibres are dispersed uniformly throughout the mass of the concrete. The fibre reinforced concrete is, playing an important role in the construction industry. The even distribution of fibres not only improve the tensile strength of concrete but also increase in the compressive strength, flexural strength, impact strength, wear and tear resistance etc. The fibre reinforced concrete has already found a wide range of practical application and has proved reliable in construction and is a material having superior performance characteristics compared to the conventional concrete. Many types' fibres can be used for the production of fibre reinforced concrete. Many types of fibres like steel, carbon, GI, glass, asbestos fibres can be used for the production of fibre reinforced concrete. Many natural fibres and mineral fibres are also being used.*

In this paper an attempt has been made to study the properties of waste plastic fibre, in the concrete, which is causing environmental pollution. The plastic is a non bio-degradable material. Hence plastic do not decay. Thus they cause the air watered ground pollution. In this experimentation the study of waste plastic plastic fibre reinforced concrete is taken up with different aspect ratios like 0, 30, 50, 70, 90, and 110. Thus the strength and workability characteristics of waste plastic fibre reinforced concrete are found in this experimentation.

Keywords: *Fibre reinforced concrete, Waste plastic fibres, Aspect ratio, Strength and workability characteristics*

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1.0 INTRODUCTION

It has been found that the addition of small closely spaced and uniformly distributed fibres to concrete would act as crack arrestors and substantially improve the tensile strength, cracking resistance, impact strength, wear and tear and fatigue resistance. The ductility of the concrete increases by the addition of fibres. Such a composite material is called fibre reinforced concrete.

The fibre reinforced concrete is very much attracting the attention of researchers and builders as it has several applications in the civil engineering field. It is used for the production of pre-casting elements like pipes, hulls of ships, railway sleepers, beams, stairways, wall panels, roof panels, roof and floor tiles, manhole covers etc. in its advanced applications FRC can be used in highway payments, airport runway, deck slab construction, water retaining structures, marine structures, blast resistance structures, refractory structures etc.

Many types of fibres can be used in the production of FRC like Steel, carbon, aluminum, Asbestos, glass, nylon, Polypropylene, Polyester, Jute, Coir etc.

Even the plastic fibres can be used in the production of FRC. The plastic is becoming a real headache for the environmentalists. The plastic is not biodegradable material. Soil cannot decay it. Water cannot dissolve or disintegrate it. But heat/fire can burn. But the moment the plastic is burnt, many toxic gases are produced and cause the air pollution. The inhalation of such toxic gases is very dangerous to health. Sustainable /safe methods of plastic destruction are not yet invented.

2.0 EXPERIMENTAL WORK

2.1 MATERIALS USED

Cement: The cement used in the experimentation was 53-grade ordinary port land cement, which satisfies the requirements of IS: 12269-1987 specifications.

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 conformed to grading zone-III as per IS: 383-1970 specification.

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.

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).

Fibres: The waste plastic fibres were obtained by cutting waste plastic pots. The waste plastic fibres obtained were all recycled plastics. The plastic fibres were not obtained from granules. The fibres were cut from steel wire cutter and it is labour oriented.

2.2 EXPERIMENTAL PROCEDURE

The main objective of this experimental investigation is to find out the effect of different aspect ratios of waste plastic fibres on the workability and strength characteristics of fibre reinforced concrete

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 aspect ratios of fibres like 0, 30, 50, 70, 90, and 110 were adopted in the experimental programme. Waste plastic fibres were added in the dry mix at the rate of 0.5% (by volume fraction). The entire mix was homogeneously mixed with calculated quantity of water and plasticizer. The compressive strength test specimens were of dimensions 150 x 150 x 150mm. The split tensile strength test specimens were of dimensions 150mm diameter x 300mm length. The flexural strength test specimens were of dimensions 100 x 100 x 500mm and impact strength test specimens were of dimensions 250 x 250 x 30 mm. These specimens were cast and tested after 28 days of curing as per IS specifications. When the mix was wet the workability test like slump test, compaction factor test and flow tests were carried out.

After 28 days of water curing the specimens were weighed for their density and tested for their strength. 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.

3.0 EXPERIMENTAL RESULTS

The following Tables give the details of the experimental results

3.1 COMPRESSIVE STRENGTH TEST RESULTS -The following Table No 3.1.1 gives the compressive strength test results of waste plastic fibre reinforced concrete with different aspect ratio of fibres.

Table 3.1.1: Compressive strength test results of waste plastic fibre reinforced concrete with different aspect ratio of fibres.

Different aspect ratio of fibres	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	81.52	24.15	24.07	608.22	27.03	27.18	---
	A	80.64	23.9		589.33	26.19		
	A	81.54	24.16		637.65	28.34		
30	B	81.9	24.26	24.16	676.89	30.08	29.64	+ 9
	B	80.95	23.98		637.65	28.34		
	B	81.5	24.14		686.7	30.52		
50	C	82.95	24.57	24.4	676.1	30.05	30.15	+ 11
	C	81.8	24.23		672	29.87		
	C	82.38	24.4		686.7	30.52		
70	D	80.9	23.97	24.04	670	29.77	29.64	+ 9
	D	81.4	24.11		664	29.51		
	D	81.2	24.05		667	29.64		
90	E	82.65	24.48	24.31	620	27.55	27.53	+ 1
	E	82.25	24.37		620	27.55		
	E	81.3	24.08		619	27.51		
110	F	82.35	24.4	24.35	552	24.53	24.56	- 10
	F	82.09	24.32		550	24.44		
	F	82.13	24.33		556	24.71		

The above results can be depicted in the form of graph as shown fig 6.1

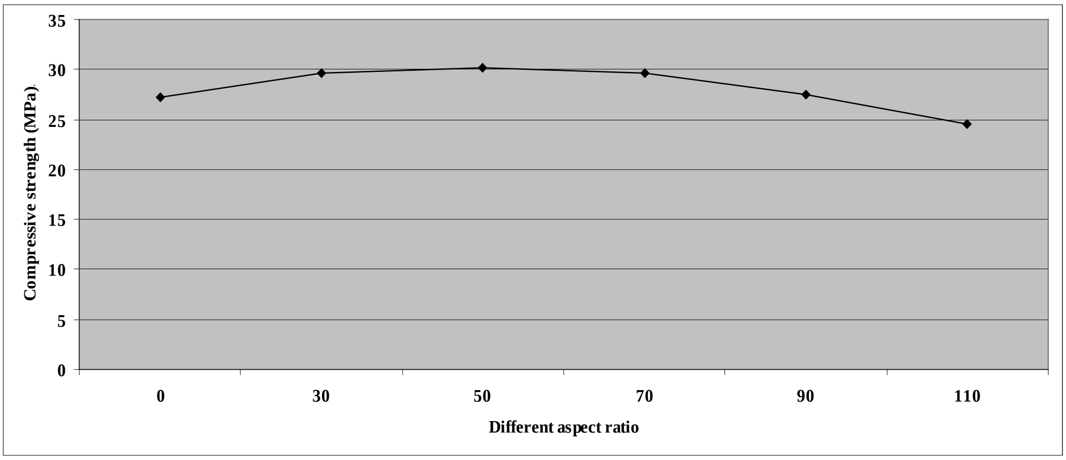

Fig 3.1: Variation of compressive strength of waste plastic fibre reinforced concrete with different aspect ratio of fibres.

3.2 TENSILE STRENGTH TEST RESULTS -The following Table No 3.2.1 gives the tensile strength test results of waste plastic fibre reinforced concrete with different aspect ratio of fibres.

Table 3.2.1: Tensile strength test results of waste plastic reinforced concrete with different aspect ratio of fibres.

Different aspect ratio of fibres	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	206	2.91	2.84	---
	A	191.3	2.7		
	A	206	2.91		
30	B	206	2.91	3.08	+ 8
	B	206	2.91		
	B	245.25	3.46		
50	C	220.72	3.12	3.2	+ 13
	C	225.63	3.18		
	C	235.44	3.32		
70	D	206	2.91	2.86	+ 1
	D	206	2.91		
	D	196.2	2.76		
90	E	181.48	2.56	2.58	- 9
	E	186.4	2.62		
	E	181.48	2.56		
110	F	161.86	2.28	2.4	- 15
	F	171.67	2.42		
	F	176.58	2.48		

The above results can be depicted in the form of graph as shown fig 3.2

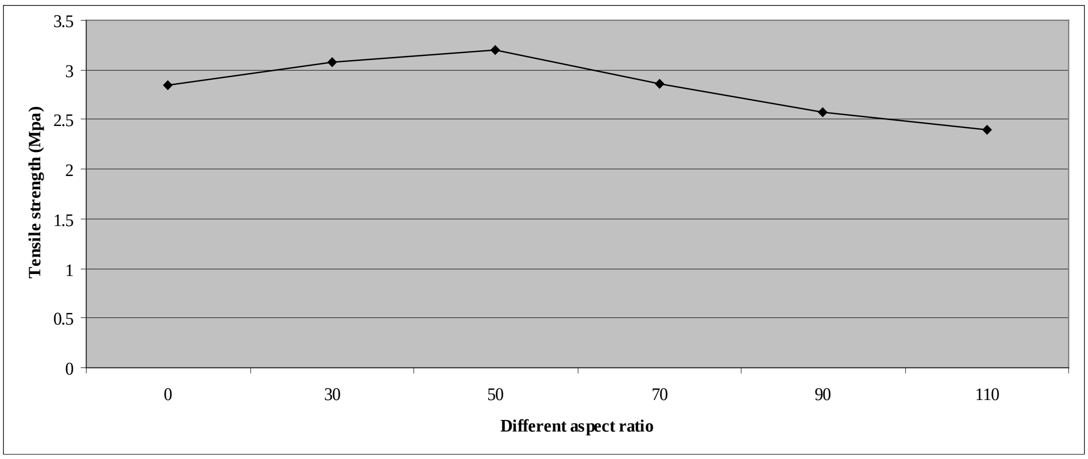

Fig 3.2: Variation of tensile strength of waste plastic fibre reinforced concrete with different aspect ratio of fibres

3.3 FLEXURAL STRENGTH TEST RESULTS -The following Table No 3.3.1 gives the flexural strength test results of waste plastic fibre reinforced concrete with different aspect ratio of fibres.

Table 3.3.1: Flexural strength test results of waste plastic reinforced concrete with different aspect ratio of fibres.

Different aspect ratio of fibres	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	13.73	5.49	5.67	---
	A	14.91	5.96		
	A	13.93	5.57		
30	B	14.32	5.72	5.85	+ 3
	B	14.12	5.65		
	B	15.49	6.19		
50	C	16.08	6.43	6.23	+ 10
	C	14.22	5.68		
	C	16.38	6.55		
70	D	12.75	5.1	5.49	- 3
	D	13.73	5.49		
	D	14.71	5.88		
90	E	10	4	4.52	- 20
	E	12.16	4.86		
	E	11.77	4.71		
110	F	9.81	3.91	3.92	- 31
	F	10.4	4.15		
	F	9.32	3.72		

The above results can be depicted in the form of graph as shown fig 3.3

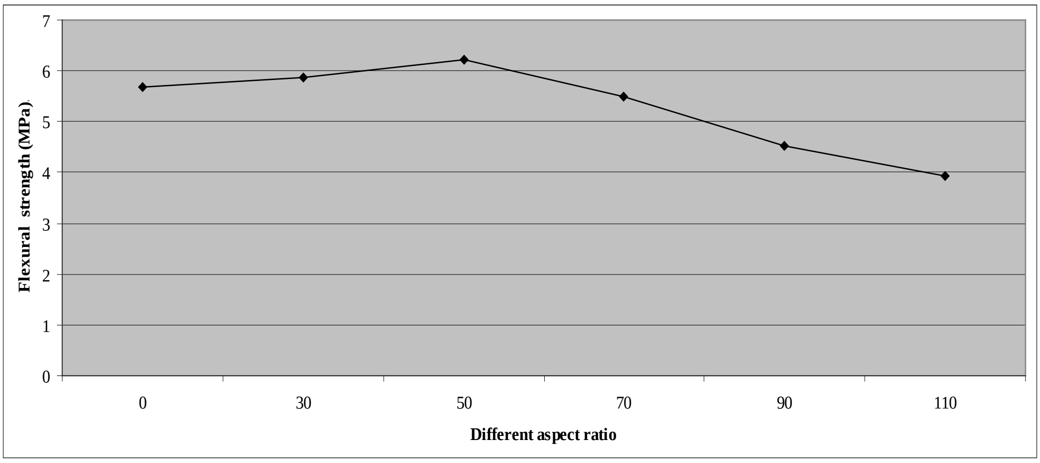

Fig 3.3: Variation of flexural strength of waste plastic fibre reinforced concrete with different aspect ratio of fibres.

3.4 IMPACT STRENGTH TEST RESULTS -The following Table No 3.4.1 gives the impact strength test results of waste plastic fibre reinforced concrete with different aspect ratios of fibres.

Table 3.4.1: Impact strength test results of waste plastic reinforced concrete with different aspect ratio of fibres

Different aspect ratio of fibres	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	2	11	4	10	39.55	98.88	---	---
	A	6	9						
	A	4	10						
30	B	6	11	6	12	59.33	118.66	+ 50	+ 20
	B	7	13						
	B	5	12						
50	C	7	23	6	21	59.33	207.65	+ 50	+ 110
	C	6	19						
	C	5	21						
70	D	6	14	5	16	49.44	158.21	+ 25	+ 60
	D	4	17						
	D	5	17						
90	E	4	13	4	14	39.55	138.43	+ 0	+ 40
	E	5	14						
	E	3	15						
110	F	4	13	4	13	39.55	128.55	+ 0	+ 30
	F	5	13						
	F	3	13						

The above results can be depicted in the form of graph as shown fig 3.4

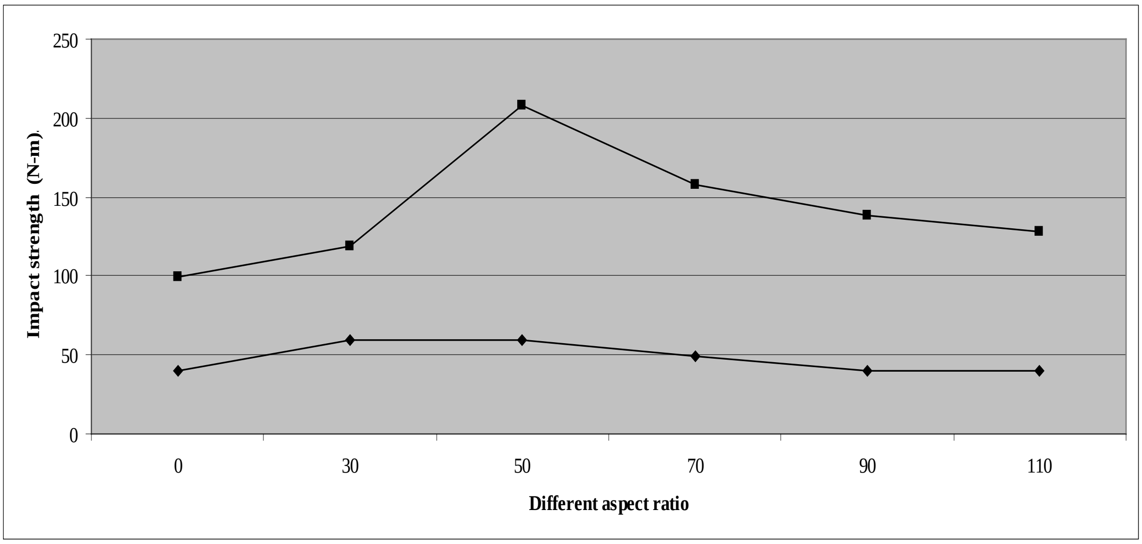

Fig 3.4: Variation of impact strength of waste plastic fibre reinforced concrete with different aspect ratio of fibres

3.5 WORKABILITY TEST RESULTS -The following Table No 3.5.1 gives the overall results of workability of waste plastic fibre reinforced concrete with different aspect ratio of fibres.

Table 3.5.1: Workability of waste plastic reinforced concrete with different aspect ratio of fibres

Different aspect ratio of fibres	Workability through		
	Slump (mm)	Compaction factor	Percentage flow
0 (Ref mix)	0	0.91	13
30	0	0.92	16
50	0	0.97	18
70	0	0.95	17
90	0	0.93	17
110	0	0.92	16

The above results can be depicted in the form of graph as shown fig 3.5 to 3.7

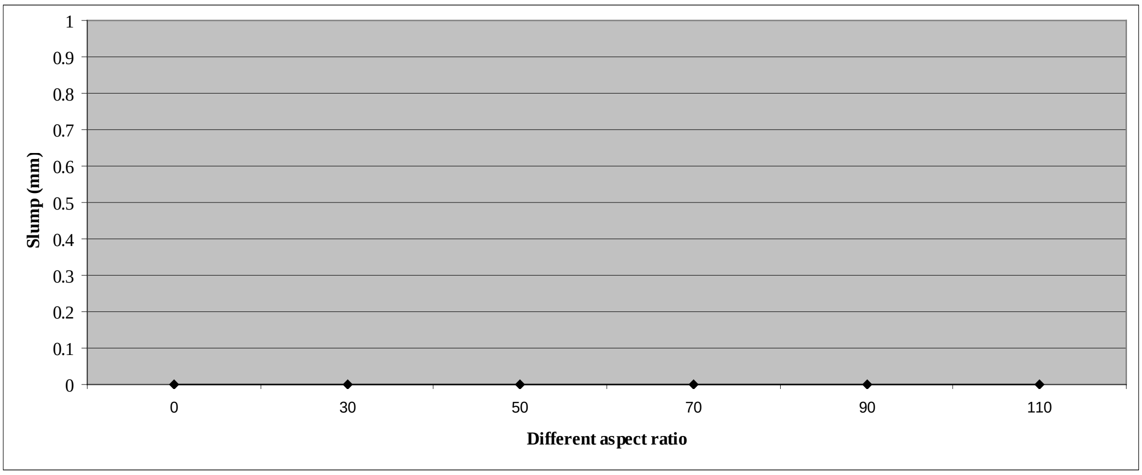

Fig 3.5: Variation of slump of waste plastic fibre reinforced concrete with different aspect ratio of fibres

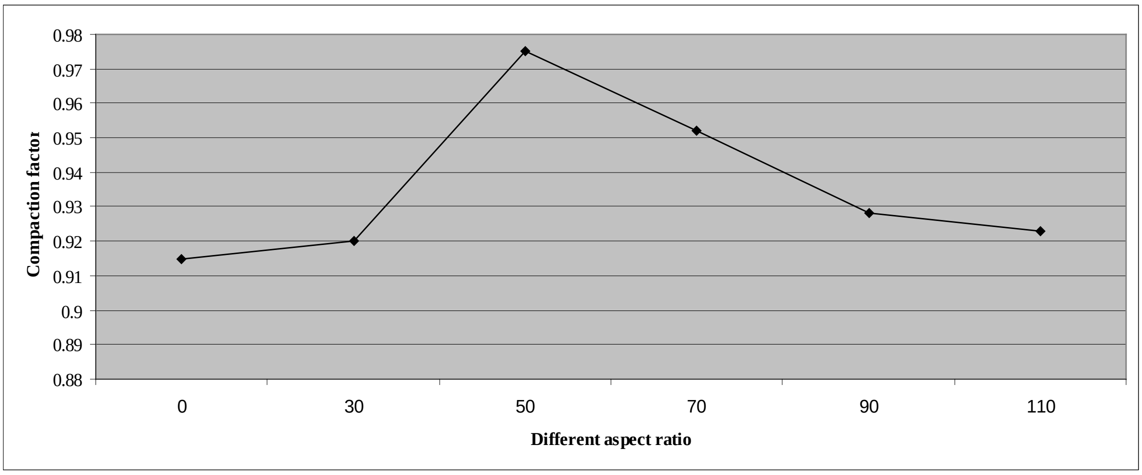

Fig 3.6: Variation of compaction factor of waste plastic fibre reinforced concrete with different aspect ratio of fibres

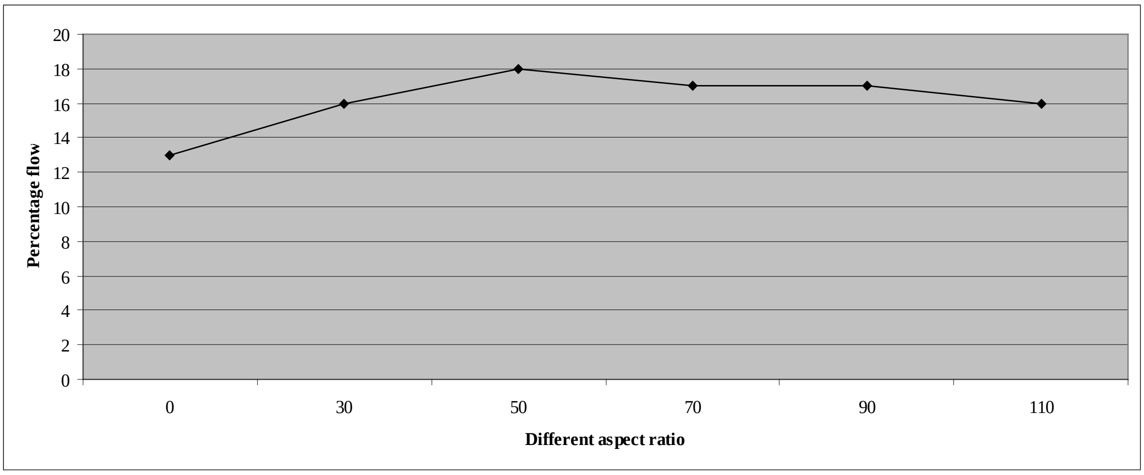

Fig 3.7: Variation of percentage flow of waste plastic fibre reinforced concrete with different aspect ratio of fibres

4.0 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 from zero aspect ratio to 50 aspect ratio. After an aspect ratio of 50, the compressive strength goes on decreasing. Therefore, the higher compressive strength can be achieved for the aspect ratio of 50 and the percentage increase in the compressive strength is 11%

It has been observed that the waste plastic fibre reinforced concrete shows an increasing trend in the tensile strength from zero aspect ratio to 50 aspect ratio. After an aspect ratio of 50, the tensile strength goes on decreasing. Therefore, the higher tensile strength can be achieved for the aspect ratio of 50 and the percentage increase in the tensile strength is 13%

It has been observed that the waste plastic fibre reinforced concrete show an increasing trend in the flexural strength from zero aspect ratio to 50 aspect ratio. After an aspect ratio of 50, the flexural strength goes on decreasing. Therefore, the higher flexural strength can be achieved for the aspect ratio of 50 and the percentage increase in the flexural strength is 10%

It has been observed that the waste plastic fibre reinforced concrete show an increasing trend in the impact strength from zero aspect ratio to 50 aspect ratio. After an aspect ratio of 50, the impact strength goes on decreasing. Therefore, the higher impact strength can be achieved for the aspect ratio of 50 and the percentage increase of impact strength for first crack and for final failure are 50% and 110% respectively

This may be due to the fact that at an aspect ratio of 50, the fibres may interlock tightly with the aggregates thus giving rise to a concrete mass with less voids and this is responsible for higher strength characteristics.

Thus from the strength point of view an aspect ratio of 50 is a good aspect ratio and most suitable for the production of waste plastic fibre reinforced concrete

2. The waste plastic fiber reinforced concrete shows an increasing trend in the workability (measured from slump, compaction factor and flow) from zero aspect ratio to 50 aspect ratio. After an aspect ratio of 50, the workability goes on decreasing. Therefore an

aspect ratio of 50 is a good aspect ratio from the workability point of view. Therefore, higher workability can be achieved for the aspect ratio of 50

This may be due to the fact that beyond an aspect ratio of 50, the waste plastic fibres may obstruct the flow with inconvenience of interlocking with the aggregates.

Thus it can be concluded that aspect ratio 50 is a good aspect ratio for the production of waste plastic fibre reinforced concrete and it yield good workability to waste plastic fibre reinforced concrete.

3. It is observed from the literature (Rafat Siddique) that the steel fibre reinforced concrete with an aspect ratio of 55 and percentage of steel fibre 0.5% results in 8%, 20% and 10% increase in the compressive strength, tensile strength and flexural strength as compared to 11%, 13% and 10% increase in the compressive strength, tensile strength and flexural strength for waste plastic fibre reinforced concrete respectively.

Thus, waste plastic fibre reinforced concrete can be compared with that of steel fibre reinforced concrete

5.0 CONCLUSIONS

1. It can be concluded that an aspect ratio of 50 is a good aspect ratio for the production of waste plastic fibre reinforced concrete and it yields maximum strength characteristics and good workability

2. Thus the waste plastics, which are environmental pollutants, can be used in the production of waste plastic fiber reinforced concrete.

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