MECHANICAL PROPERTIES OF CONCRETE CONTAINING HIGH VOLUME POND-ASH AND STEEL FIBRE

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Abstract : The experimental investigation is to study the effects of replacement of cement (by weight) with two percentage of pond ash and the effects of addition of steel fibre composite. Mix design has been done in accordance with IS:10262-2009. Cement was replaced with two percentages of high volume (40%, 60%) of pond ash. Four percentages of steel fibres (0%, 1%, 1.5% and 2%) having 50mm length and diameter 1 mm were used. Mechanical properties such as compressive strength, flexural and split tensile strength tests have been carried out and the obtained results were compared with control mix.

Key words: Pond ash; steel fibre; compressive strength, split tensile strength; flexural strength.

1. Introduction

The usage of industrial waste materials in concrete, both in regard to environmental pollution and the positive effect on a country's economy are beyond dispute. Utilization of fly ash (FA) in concrete technology is more common. FA causes environmental pollution and the cost of storage of FA is very high. When some types of FA replaces with cement in concrete mixture, fresh concrete workability is increased, early strength and shrinkage of hardened concrete are decreased, and permeability is decreased due to filling the micro-pores of concrete. Fibres used in concrete are produced from a wide variety of materials, those being composed of glass, ceramic, steel, organic and some polymer materials. Unused fly ash and bottom ash from thermal power plants, mixed in slurry form and deposited in ponds, is known as Pond Ash. Studies on pond-ash in concrete showed that slump and air content of pond-ash might greatly differ according to the place of generation, which might also have a huge influence on the absorption and grading of pond-ash. Experimental studies showed that fibres improve the mechanical properties of concrete such as flexural strength, compressive strength, tensile strength, creep behaviour, impact resistance and toughness. There is not enough study carried out on fibre reinforced concrete produced with FA.Researchers have studied pond ash concrete and fibre reinforced concrete separately; however, considering reinforcing fibres with ash in concrete is an area that needs more study. The purpose of this research is to study the effects of pond ash and steel fibres on compressive strength, flexural tensile strength, splitting tensile strengths in concrete.

2. Experimental Investigation

2.1 Cement

The cement used was ordinary Portland cement 53 (OPC 53).The specific gravity of cement was found to be 3.15. The initial and final setting times were found as 55 minutes and 258 minutes respectively. Standard consistency of cement was 30%.

2.2 Coarse Aggregate

The coarse aggregates of size 20mm and 12 mm were used. The specific gravity was found to be 2.78. Fineness modulus of coarse aggregate was found to be 7.

2.3 Fine aggregate

The sand which was locally available and passing through 4.75mm IS sieve is used. The specific gravity of fine aggregate was found to be 2.60.

2.4 Steel fibres

The length of fibre was 50mm and the diameter of fibre is 1mm. Its aspect ratio was found to be 50. The tensile strength of the fibre was found to be 1098 MP a using tensometer. Fibre content was varied as 0%, 1%, 1.5% and 2% by volume of concrete.

2.5 Pond ash

Pond ash collected from Thermal power station located in Mettur (Salem District) was used in this work. The specific gravity of pond ash was found to be 2.04.Pond ash content was varied as 0%, 40% and 60% by the weight of cement.

Table 1 Chemical compositions of cement and pond ash (%)

Parameter	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	SO_3	K_2O	Na_2O	LOI
Cement	19.94	5.15	3.38	63.37	1.58	1.93	0.90	0.24	0.98
Pond ash	54.46	33.11	1.76	7.97	0.35	1.20	0.00	0.00	2.16

2.6 Preparations of mixtures

For each cubic meter of concrete, w/c+pond ash ratio was determined according to the pond ash content, and the mix was prepared accordingly. Mixture

design was made in accordance with the Indian Standard Code 10262-2009 [25]. Fresh concretes containing 40% and 60% pond ash as cement replacement in mass basis were prepared by modifying the reference Portland cement concrete. Similarly, fresh fibre reinforced concretes containing 1%, 1.5% and 2.0% steel fibre in volume basis were also prepared. Mechanical properties such as compressive strength, split tensile strength and flexural strength tests have performed and following discuss the results of it.

3. Results and Discussion

3.1 Compressive strength

Figure 1, 2 and 3 shows the graphical pattern of compressive strength for a curing period of 7 days, 28 day and 90 days. At 0% pond-ash and 2% steel fibres maximum compressive stress is obtained which is to a good extent compensated by 40% pond-ash and 2% steel fibres when the curing period was 7 days. For the curing period of 28 days, at 0% pond-ash and 2% steel fibres maximum compressive stress is obtained which is to a good extent compensated by 40% pond-ash and 2% steel fibres. At 0% pond ash and 2% steel fibres maximum compressive stress is obtained which is to a good extent compensated by 40% pond ash and 2% steel fibres. Table 2 shows the results of compressive strength for curing periods of 7 days, 28 days and 90 days.

Table 2 Compressive strength

Pond ash	Steel fibres	Compressive strength (N/mm^2)		
		7 days	28 days	90 days
0%	0%	29.5	40.3	42.90
	1%	34.85	40.7	44.50
	1.50%	36.25	42.55	46.05
	2%	38.95	46.85	49.05
40%	0%	23.6	26.05	35.20
	1%	26.55	38.2	40.55
	1.50%	28.5	40.05	43.05
	2%	34.6	45.55	48.80
60%	0%	16.75	24.85	29.15
	1%	19.5	27.35	34.40
	1.50%	22	31.65	36.55
	2%	26.25	39.4	42.25

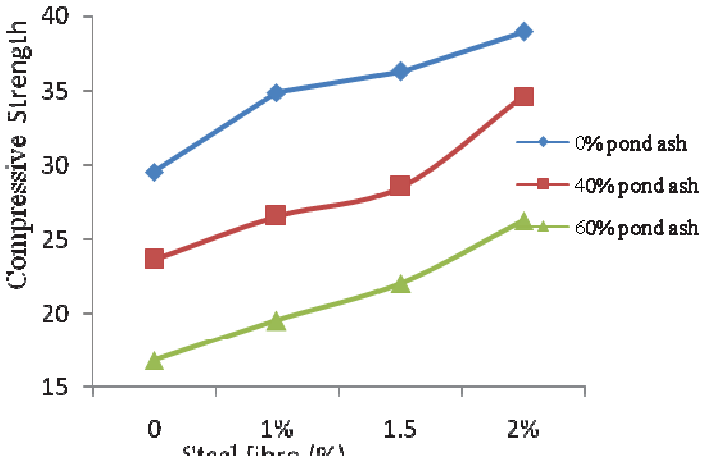

Figure 1 Compressive strength for curing periods of 7 days

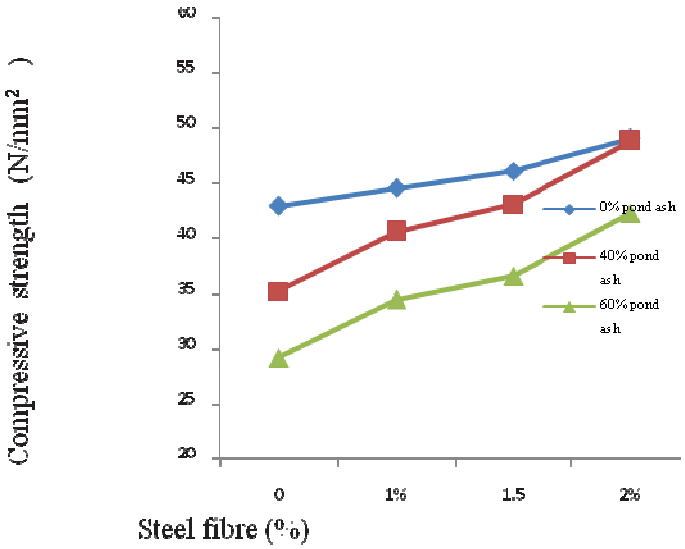

Figure 2 Compressive strength for curing periods of 90 days

3.2 Split tensile test

Table 3 shows the result of split tensile strength. As the steel fibres increases the split tensile stress increases. Figures 4, 5 and 6 shows the results of split tensile strength for a curing period of 7 days, 28 days and 90 days. The split tensile stress at 40% pond-ash and 2% steel fibre is almost same as 0% pond-ash and 2% steel fibres at which maximum split tensile stress is obtained. As the steel fibres increases the split tensile stress increases. For 28 days curing period the split tensile stress at 40% pond-ash and 2% steel fibre is almost same as 0% pond-ash and 2% steel fibres at which maximum split tensile stress is obtained. So it is economical to use 40 % pond-ash and 2 % steel fibre composition. For 90 days curing period the split tensile stress results shows that as the steel fibres increases the split tensile stress increases. The split tensile stress at 40% pond-ash and 2% steel fibre is almost same as 0% pond-ash and 2% steel fibres at which maximum split tensile stress is obtained. So it is economical to use 40 % pond-ash and 2 % steel fibre composition.

Table 3 Split tensile strength

Pond ash	Steel fibres	Split tensile strength (N/mm^2)		
		7 days	28 days	90 days
0%	0%	1.81	2.53	3.24
	1%	2.65	3.12	3.67
	1.50%	2.84	3.58	4.13
	2%	2.88	4.37	5.57
40%	0%	1.81	2.24	2.96
	1%	2.33	2.91	3.34
	1.50%	2.54	3.45	3.61
	2%	2.78	3.91	5.47
60%	0%	1.32	2.13	2.59
	1%	1.55	2.45	2.89
	1.50%	1.78	2.54	3.29
	2%	1.87	2.88	4.56

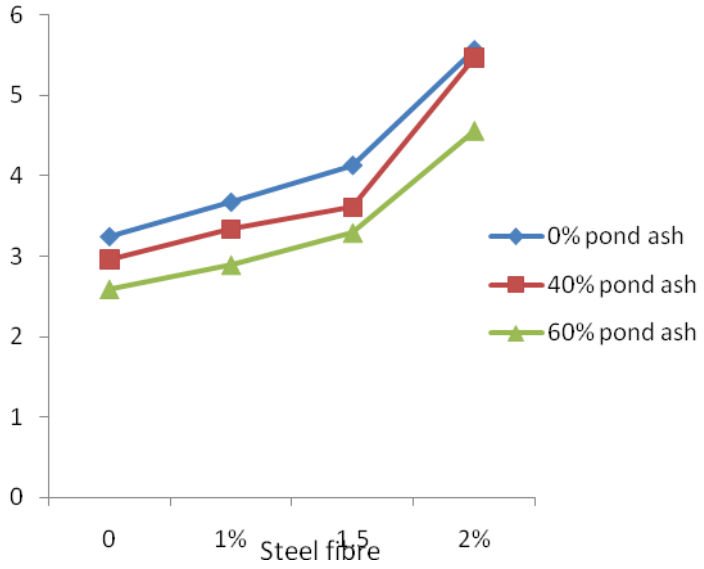

Figure 4 Split tensile strength for curing periods of 90 days

3.3. Flexural strength test

As the steel fibres increases the flexural stress increases. The split tensile stress at 40% pond-ash and 2% steel fibre is almost same as 0% pond-ash and 2% steel fibres at which maximum flexural stress is obtained. For 28 days curing period, as the steel fibres increases the flexural stress increases. The flexural stress at 40% pond-ash and 2% steel fibre is almost same as 0% pond-ash and 2% steel fibres at which maximum flexural stress is obtained. So it is economical to use 40 % pond ash and 2 % steel fibre composition. For curing period of 90 days flexural strength results shows that as the steel fibres increases the flexural stress increases. The flexural strength at 40% pond-ash and 2% steel fibre is maximum among all other designs.

Table 4 Flexural strength

Pond ash	Steel fibres	Flexural strength (N/mm²)		
		7 days	28 days	90 days
0%	0%	4	5.5	6.1
	1%	4.5	6.3	6.9
	1.50%	4.6	6.24	7.1
	2%	5.4	6.8	9.28
40%	0%	3.4	5.4	6.08
	1%	5.3	7.7	8.68
	1.50%	5.3	9.2	9.36
	2%	5.9	11.96	12.16
60%	0%	3.3	6.6	5.72
	1%	3.7	5.1	6.3
	1.50%	3.9	5.1	6.32
	2%	4.2	6.6	7.8

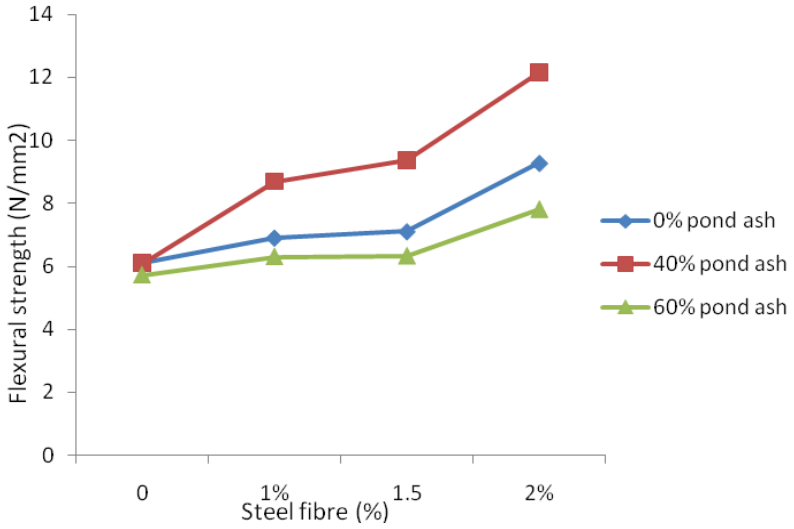

Figure 9 Flexural strength for curing periods of 90 days

4. Conclusions

1. Specimens containing 2% steel fibres with 40% replacement of cement by pond ash are more effective in resisting flexural tensile stresses as well as compressive stresses. Hence, the optimum percentage of steel fibre fly ash reinforced concrete is around 2% of steel fibres and 40% of pond ash.

2.As the cement is reduced by 40% the concrete prepared is cost effective and environmental friendly .

3.The workability of concrete is improved considerably by addition of ponash.

4.With the addition of steel fibres and flyash in concrete ductility is improved considerably.

5. The ratio of tensile strength to compressive strength can be enhanced by reduction of flash and the reduction of steel fibres

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