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RESEARCH ARTICLE

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EFFECT OF PARTIAL REPLACEMENT OF NATURAL SAND BY FLY ASH ON THE PROPERTIES OF HYBRID FIBRE REINFORCED CONCRETE

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ABSTRACT

Cement, sand and coarse aggregate are the primary requirements for any construction industry. Natural sand is a main material used as a fine aggregate for preparation of mortar and concrete, and plays a main role in mix design. Due to the large use of concrete and mortar, utilization of natural sand is high. Hence demand for fine aggregate is increasing day by day in India to satisfy the requirement of rapid infrastructure growth. Natural sand deposits are being used up and causing many serious problems to environment. Fly ash is a waste fine material produced from many thermal plants. It is commonly used as a partial replacement of cement. Fly ash can also be used for replacement of natural sand in concrete. Using fly ash in construction concrete mix with a replacement of natural sand gives the best solution to both scarcity of sand and disposal problem of fly ash.

The purpose of this investigation is to determine the effect of partial replacement of natural sand by fly ash on the properties of hybrid fibre reinforced concrete. For the study natural sand was replaced with fly ash at different percentages such as 0%, 20%, 40%, 60%, 80%, with hybrid fibre combinations (steel+polypropylene) at a volume fraction of (0.5%+0.5%) and monofibre steel and polypropylene at a volume fraction of (1%).The concrete is cured for 28days. The strength properties were studied through compressive strength, tensile strength, flexural strength, shear strength and impact strength for various replacements of sand with fly ash. Also additional test such as workability test, water absorption and soroptivity test are conducted. The work is carried out for M30 grade of concrete.

Keywords: Hybrid fibre reinforced concrete, fly ash, steel fibres, polypropylene fibres

I. INTRODUCTION

Cement, sand and coarse aggregate are the primary requirements for any construction industry. Natural sand is a main material used as a fine aggregate for preparation of mortar and concrete, and plays a main role in mix design. Due to the large use of concrete and mortar, utilization of natural sand is high. Hence demand for fine aggregate is increasing day by day in India to satisfy the requirement of rapid infrastructure growth. Natural sand deposits are being used up and causing many serious problems to environment. Losing of water retaining soil strata, deepening of river beds are some of the important examples of problems caused by rapid extraction of sand from river bed. And also due to lowering of the water table in the well, it is disturbing aquatic life and disturbing agricultural activities.

Thus, scarcity of sand is causing increasingly discomfort for people and has no practical answers to this serious problem. Industrial by-products and waste from all the industry, which are causing problems both for the society and environment can be used in construction work which will be useful for the economy point of view and also to conserve the environment. Researchers and some of the engineers come out with their own practical idea to replace natural sand partially or fully. Thus some of the industrial wastes are being effectively used in the production of concrete. Fly ash is a waste material produced from many thermal power plants. It is commonly used as a partial replacement of cement. Enough studies have been carried out with partial replacement of cement by fly ash from so many earlier researchers. Fly ash can also be used for replacement of natural sand in concrete. Using fly ash in construction concrete mix with a replacement of natural sand gives the best solution to both scarcity of sand and disposal problem of fly ash.

OBJECTIVE

The purpose of this investigation is to determine the effect of partial replacement of natural sand by fly ash on the properties of hybrid fibre reinforced concrete. For the study natural sand was replaced with fly ash at different percentages such as 0%, 20%, 40%, 60%, 80%, with hybrid fibre combinations (steel+polypropylene) at a volume fraction of (0.5%+0.5%) and monofibre steel and polypropylene at a volume fraction of (1%).The concrete is cured for 28days. The strength properties were studied through compressive strength, tensile strength, flexural strength, shear strength and impact strength for various replacements of sand with fly ash. Also additional test such as workability test, water absorption and soroptivity test are conducted. The work is carried out for M30 grade of concrete.

MATERIAL USED

In this experimental study, Cement, sand, fly ash, coarse aggregate, water, steel fibres and polypropylene fibres are used.

Cement: Ordinary Portland Cement of 43 grade was used which is confirming to IS 12269:1989

Coarse aggregate: Locally available aggregate with maximum size 20mm and with specific gravity 2.66 was used.

Sand: Locally available sand (zone II) with specific gravity 2.64, confirming to IS 383-1970 was used.

Water: Portable water was used for experiment.

Fly ash: Low calcium, class F dry fly ash from the silos of Raichur thermal power plant confirming to IS:3812(Part 1)-2003 was used.

Steel fibres: Crimped steel fibres having 35mm length and 1mm thickness leading to an aspect ratio of 35mm were used.

Polypropylene fibres: Polypropylene fibres having 12mm length were used.

METHODOLOGY

The mix design procedure adopted to obtain a M30 grade concrete is in accordance with IS 10262-2009. The final mix ratio was 1:1.485:2.542 with water cement ratio of 0.45. The specimens were casted for the different percentage of replacement of natural sand by fly ash with hybrid fibre combination. Weigh batch method was used for material mix proportions. Concrete was placed in moulds in 3 layers by tamping each layer. The specimens were casted by keeping the moulds on the vibrator for better compaction. The casted specimens were removed from moulds after 24 hours and the specimens were kept for water curing for 28 days. The strength properties were studied through compressive strength, tensile strength, flexural strength, shear strength and impact strength for various replacements of sand with fly ash.

EXPERIMENTAL RESULTS

WORKABILITY TEST RESULTS

Workability is measured through slump, compaction factor, Vee-Bee degree and percentage flow. Table 1 gives the workability test results for both monofibre reinforced concrete and hybrid fibre reinforced concrete. The variations in the workability are depicted in the form of graph.

STRENGTH TEST RESULTS

Following tables provide overall result of compressive strength, split tensile strength, flexural strength, shear strength and impact strength for different combination with various percentage replacement of natural sand by fly ash. Also they provide percentage increase in strength of hybrid fibre reinforced concrete with respect to monofibre reinforced concrete.

Table 1: Workability test results

Description of workability		Percentage replacement of natural sand by fly ash				
		0%	20%	40%	60%	80%
Slump(mm)	For monofibre reinforced concrete with SF	88	91	93	90	88
	For monofibre reinforced concrete with PPF	86	89	91	87	84
	For monofibre reinforced concrete with (SF+PPF)	87	90	92	88	86
Compaction factor	For monofibre reinforced concrete with SF	0.909	0.916	0.920	0.917	0.913
	For monofibre reinforced concrete with PPF	0.906	0.912	0.918	0.911	0.909
	For monofibre reinforced concrete with (SF+PPF)	0.907	0.914	0.919	0.915	0.911
Vee-Bee degree(sec)	For monofibre reinforced concrete with SF	106	103	99	105	113
	For monofibre reinforced concrete with PPF	96	93	92	99	111
	For monofibre reinforced concrete with (SF+PPF)	103	98	96	102	112
Percentage flow	For monofibre reinforced concrete with SF	40.24	42.50	44.35	41.72	40.32
	For monofibre reinforced concrete with PPF	39.84	40.21	42.31	39.17	37.18
	For monofibre reinforced concrete with (SF+PPF)	39.90	41.30	43.21	39.90	38.89

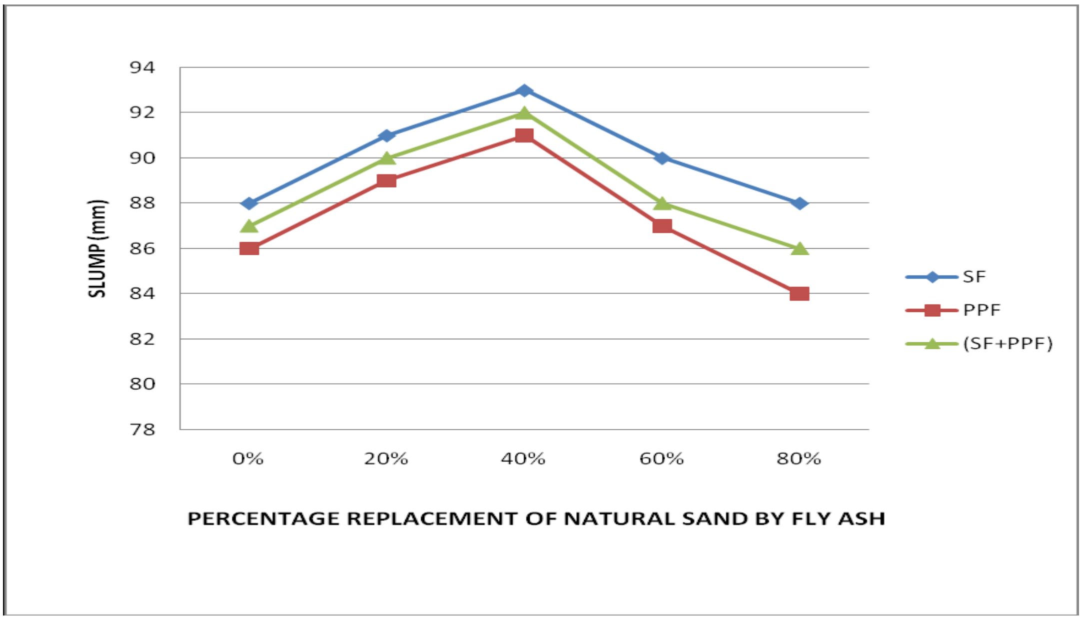

Fig 1 Variation of slump

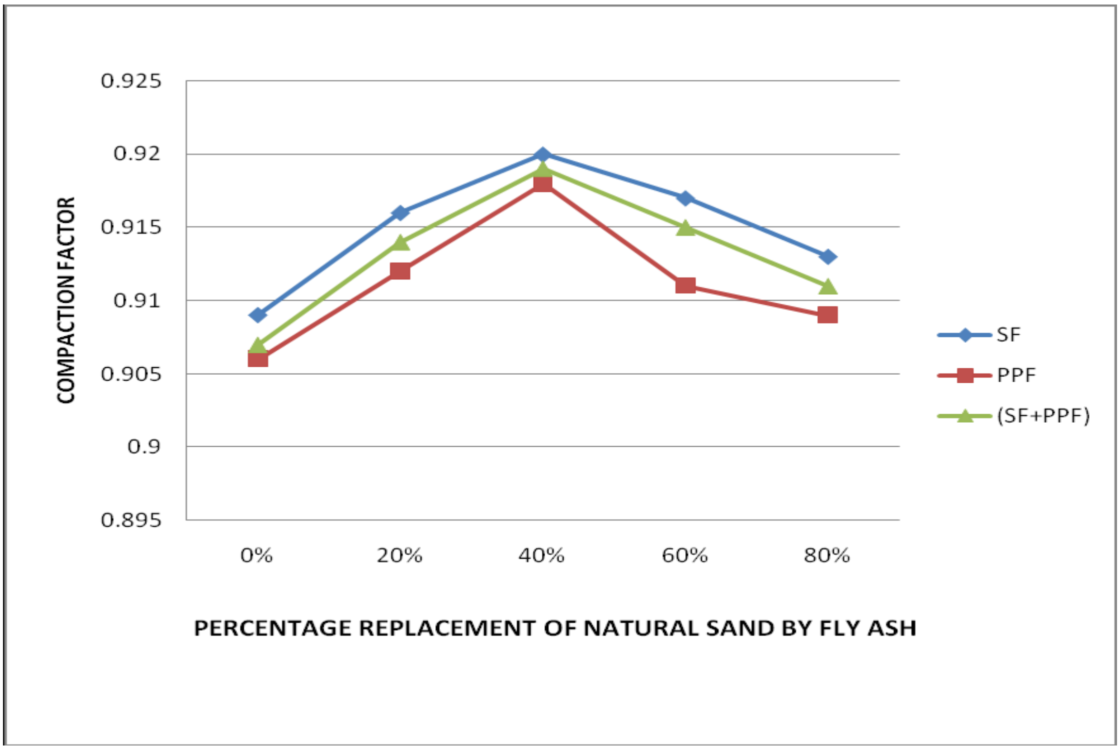

Fig 2 Variation of compaction factor values

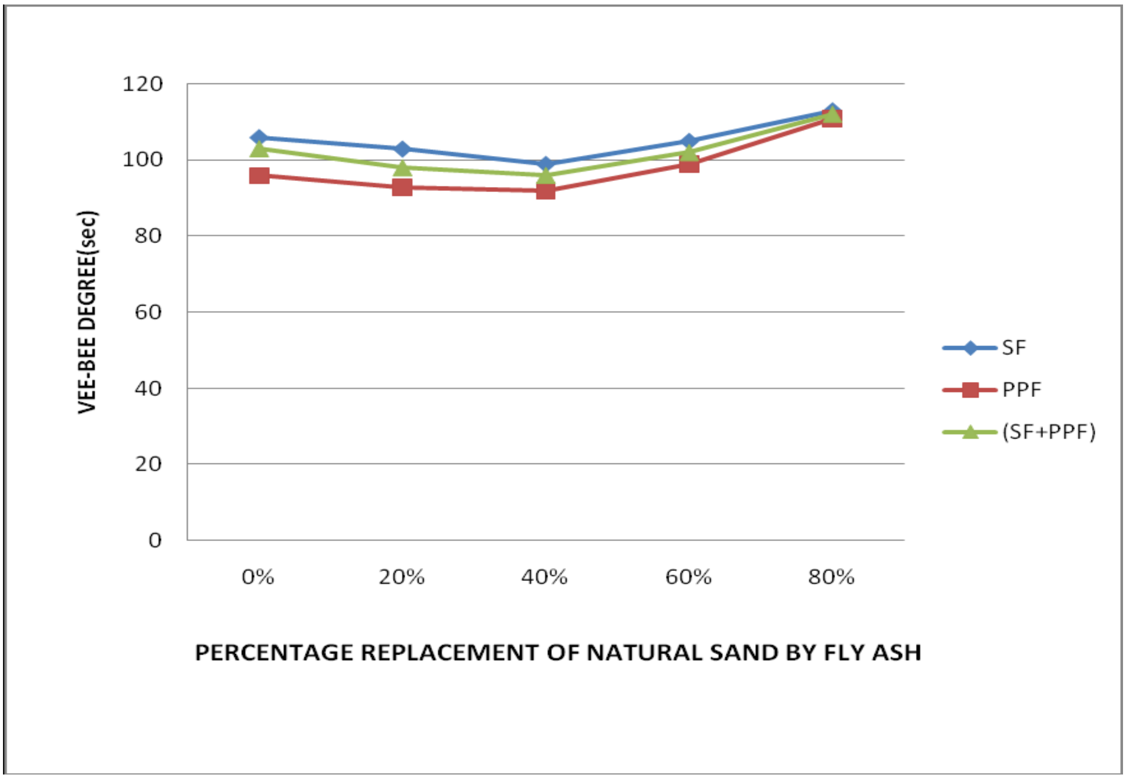

Fig 3 Variation of Vee-Bee degree

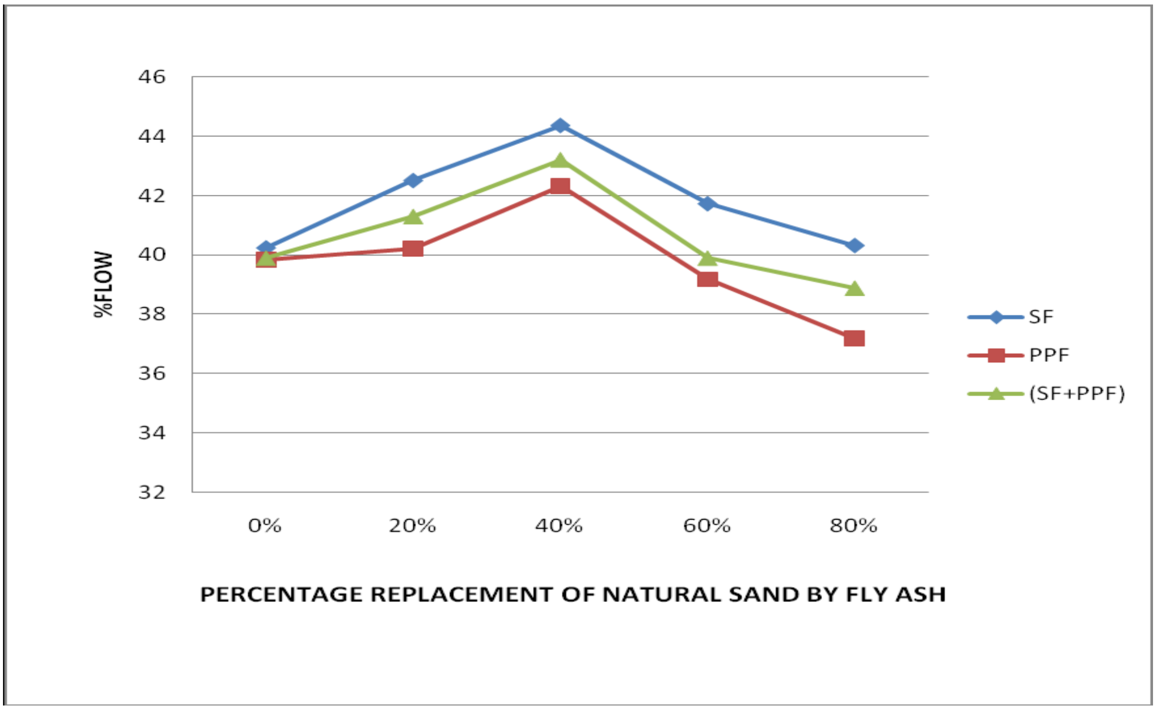

Fig 5.4 Variation of percentage flow

NEAR SURFACE CHARACTERISTIC TEST RESULTS

Description of near surface characteristic test		Percentage replacement of natural sand by fly ash				
		0%	20%	40%	60%	80%
Percentage water absorption	For monofibre reinforced concrete with SF	1.29	1.14	0.87	0.98	1.47
	For monofibre reinforced concrete with PPF	1.05	0.91	0.79	0.90	1.25
	For monofibre reinforced concrete with (SF+PPF)	1.05	0.75	0.65	0.83	1.16
soroptivity	For monofibre reinforced concrete with SF	5.80	4.10	4.50	4.87	5.16
	For monofibre reinforced concrete with PPF	5.45	4.10	3.87	4.50	4.75
	For monofibre reinforced concrete with (SF+PPF)	5.45	3.87	3.76	4.16	4.50

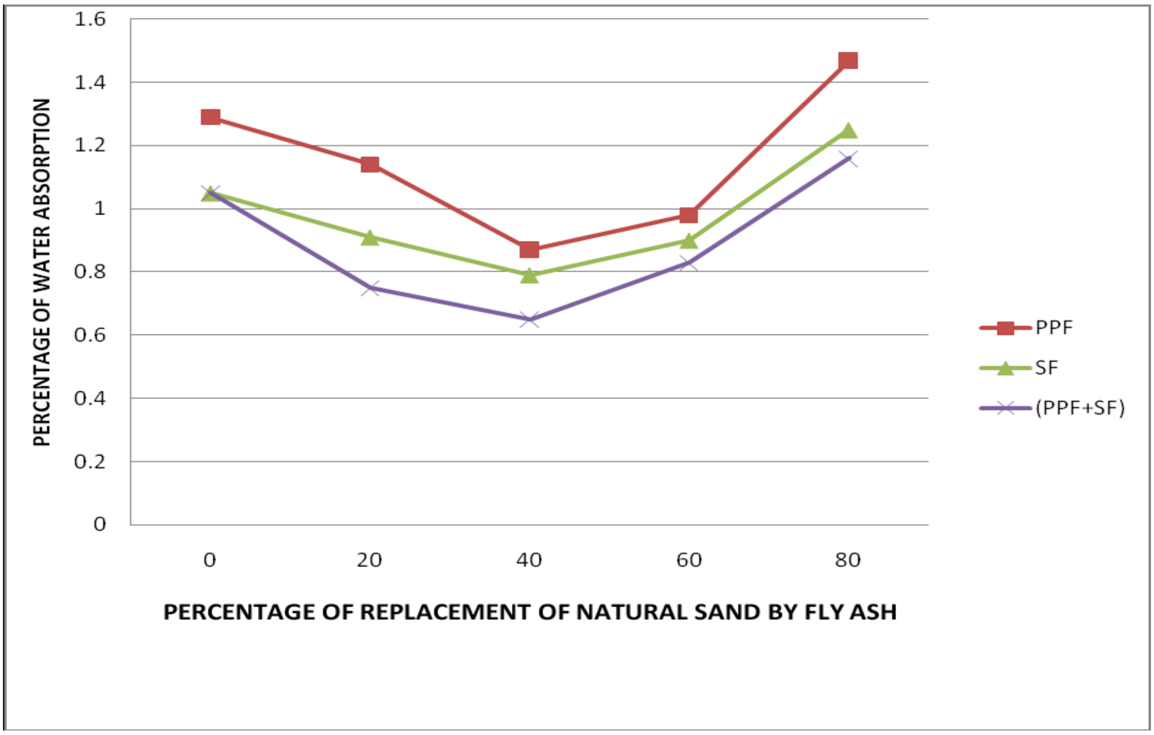

Fig 4 Variation of water absorption

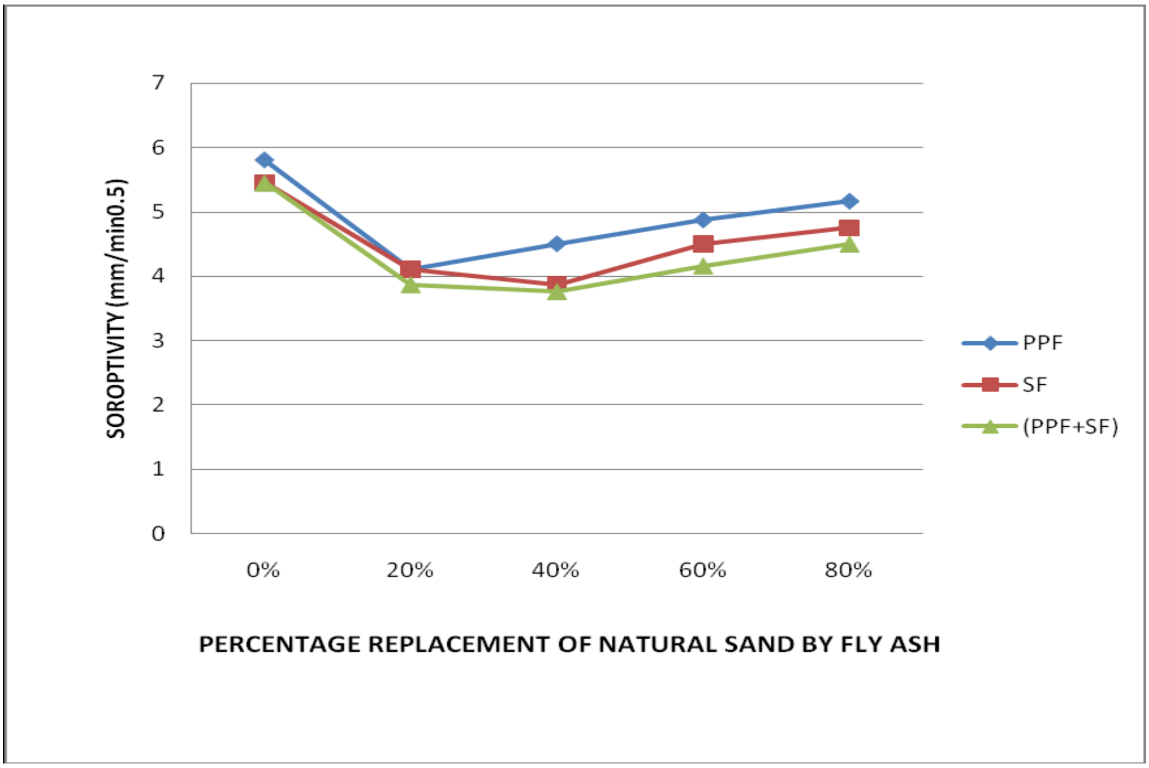

Fig 6 Variation of soroptivity

Table 3 Test result of compressive strength

Percentage replacement of natural sand by fly ash	Compressive strength of monofibre reinforced concrete with SF(MPa)	Compressive strength of monofibre reinforced concrete with PPF(MPa)	Compressive strength of hybrid fibre reinforced concrete with (SF+PPF) (MPa)	Percentage increase of compressive strength of HFRC as compared to monofibre reinforced concrete with PPF
0%	33.48	31.25	32.29	3.33
20%	34.67	31.99	33.63	5.13
40%	37.63	32.59	34.22	5.00
60%	33.18	31.85	32.19	1.70
80%	32.45	30.07	31.26	3.96

Table 4 Test result of split tensile strength

Percentage replacement of natural sand by fly ash	Split tensile strength of monofibre reinforced concrete with SF(MPa)	Split tensile strength of monofibre reinforced concrete with PPF(MPa)	Split tensile strength of hybrid fibre reinforced concrete with (SF+PPF) (MPa)	Percentage increase of split tensile strength of HFRC as compared to monofibre reinforced concrete with PPF
0%	4.71	3.68	4.10	11.41
20%	5.18	4.10	4.81	17.32
40%	6.37	4.95	5.71	15.35
60%	5.04	3.96	4.47	12.88
80%	4.34	3.34	3.72	11.37

Table 5 Test result of flexural strength

Percentage replacement of natural sand by fly ash	Flexural strength of monofibre reinforced concrete with SF(MPa)	Flexural strength of monofibre reinforced concrete with PPF(MPa)	Flexural strength of hybrid fibre reinforced concrete with (SF+PPF) (MPa)	Percentage increase of flexural strength of HFRC as compared to monofibre reinforced concrete with PPF
0%	7.33	5.53	6.93	25.32
20%	8.00	6.93	7.40	6.78
40%	9.00	7.50	8.00	6.67
60%	7.60	6.53	7.13	9.14
80%	6.93	5.30	6.60	24.53

Table 6 Test result of shear strength

Percentage replacement of natural sand by fly ash	Shear strength of monofibre reinforced concrete with SF(MPa)	Shear strength of monofibre reinforced concrete with PPF(MPa)	Shear strength of hybrid fibre reinforced concrete with (SF+PPF) (MPa)	Percentage increase of shear strength of HFRC as compared to monofibre reinforced concrete with PPF
0%	12.78	11.67	12.48	6.90
20%	14.81	12.48	13.15	5.37
40%	17.96	13.89	15.00	7.99
60%	13.70	11.48	12.41	8.10
80%	12.96	9.81	11.3	15.19

Table 7 Test result of impact strength at initial crack

Percentage replacement of natural sand by fly ash	Impact strength for monofibre reinforced concrete with SF (N-m)	Impact strength for monofibre reinforced concrete with PPF (N-m)	Impact strength for hybrid fibre reinforced concrete with (SF+PPF) (N-m)	Percentage increase of impact strength of HFRC as compared to monofibre reinforced concrete with PPF
0%	643.18	484.11	553.27	14.29
20%	684.68	574.02	636.27	10.84
40%	746.92	622.43	698.51	12.22
60%	594.77	518.69	546.36	5.33
80%	504.86	414.96	449.53	8.33

Table 8 Test result of impact strength at final failure

Percentage replacement of natural sand by fly ash	Impact strength for monofibre reinforced concrete with SF (N-m)	Impact strength for monofibre reinforced concrete with PPF (N-m)	Impact strength for hybrid fibre reinforced concrete with (SF+PPF) (N-m)	Percentage increase of impact strength of HFRC as compared to monofibre reinforced concrete with PPF
0%	746.92	546.36	615.52	12.66
20%	788.42	643.01	733.09	14.01
40%	850.64	691.59	802.25	16.00
60%	670.84	580.94	615.52	5.95
80%	601.69	484.11	518.69	7.14

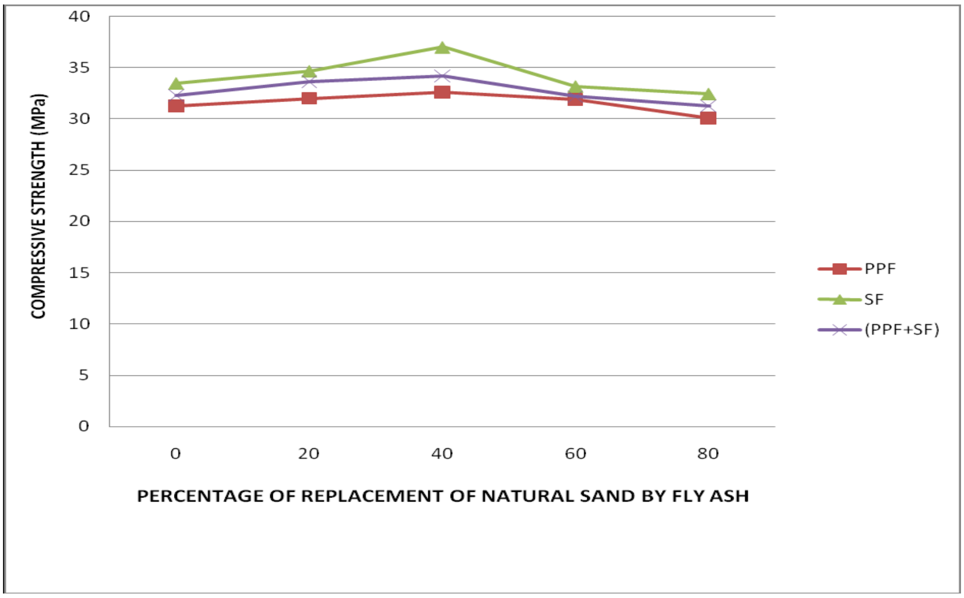

Fig 7 Variation of compressive strength

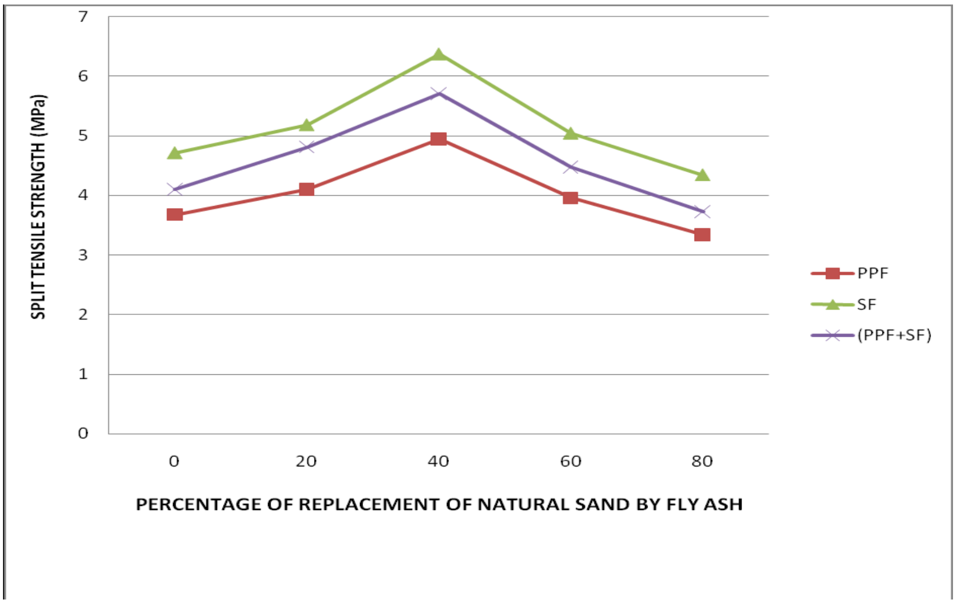

Fig 8 Variation of split tensile strength.

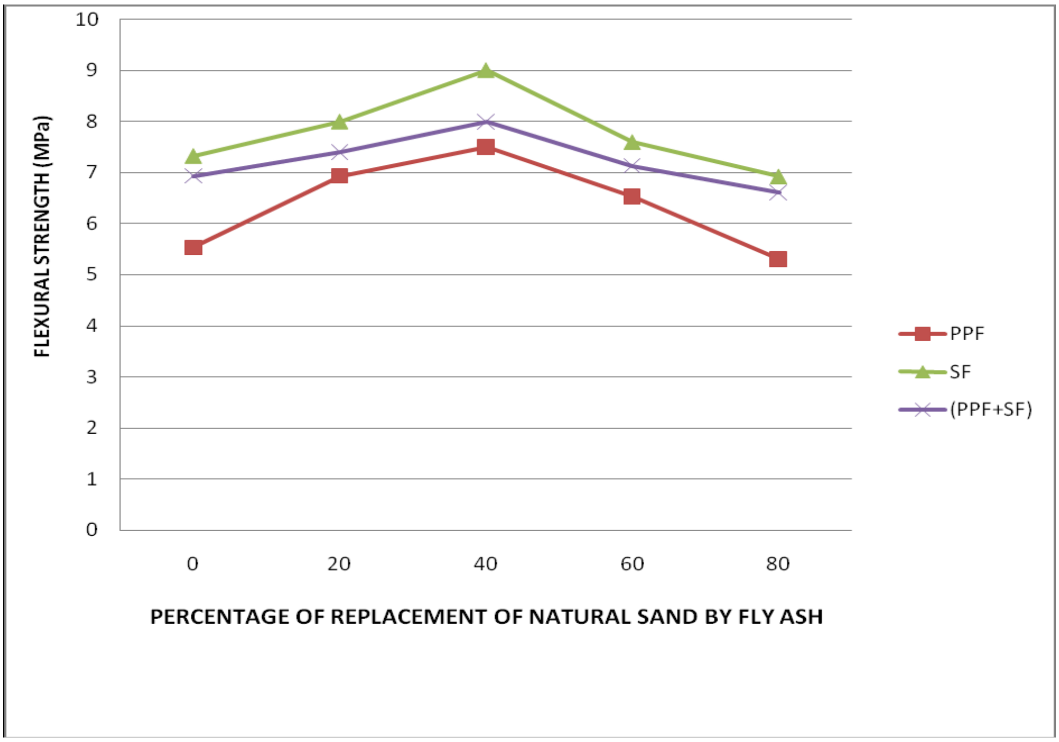

Fig 9 Variation of flexural strength.

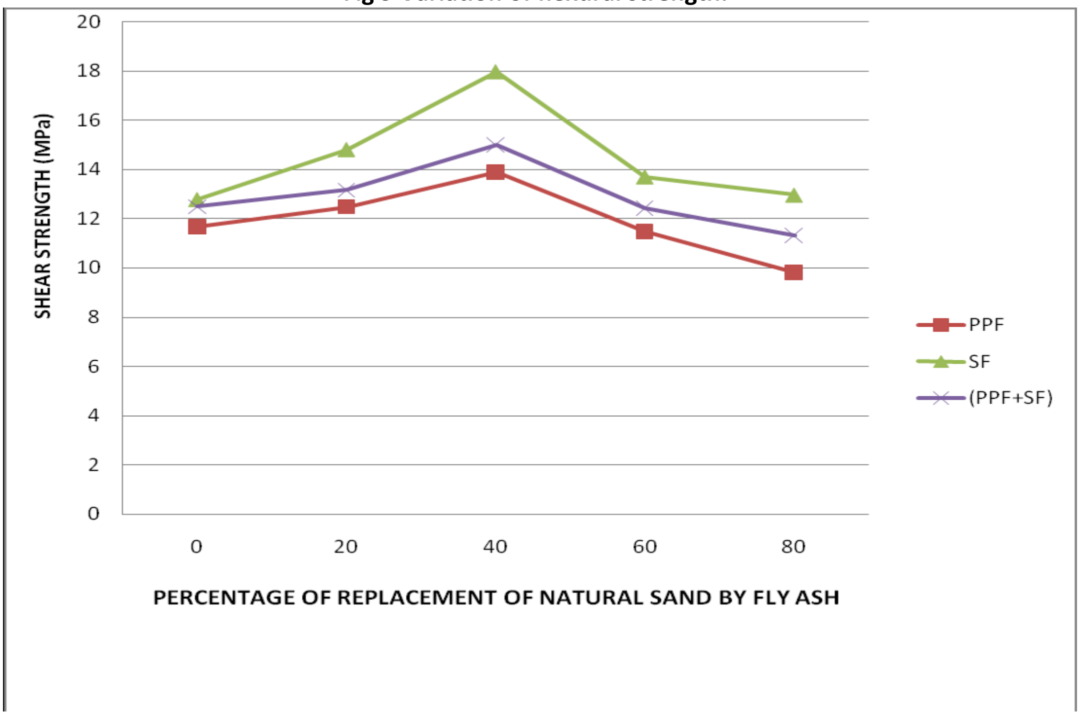

Fig 10 Variation of shear strength

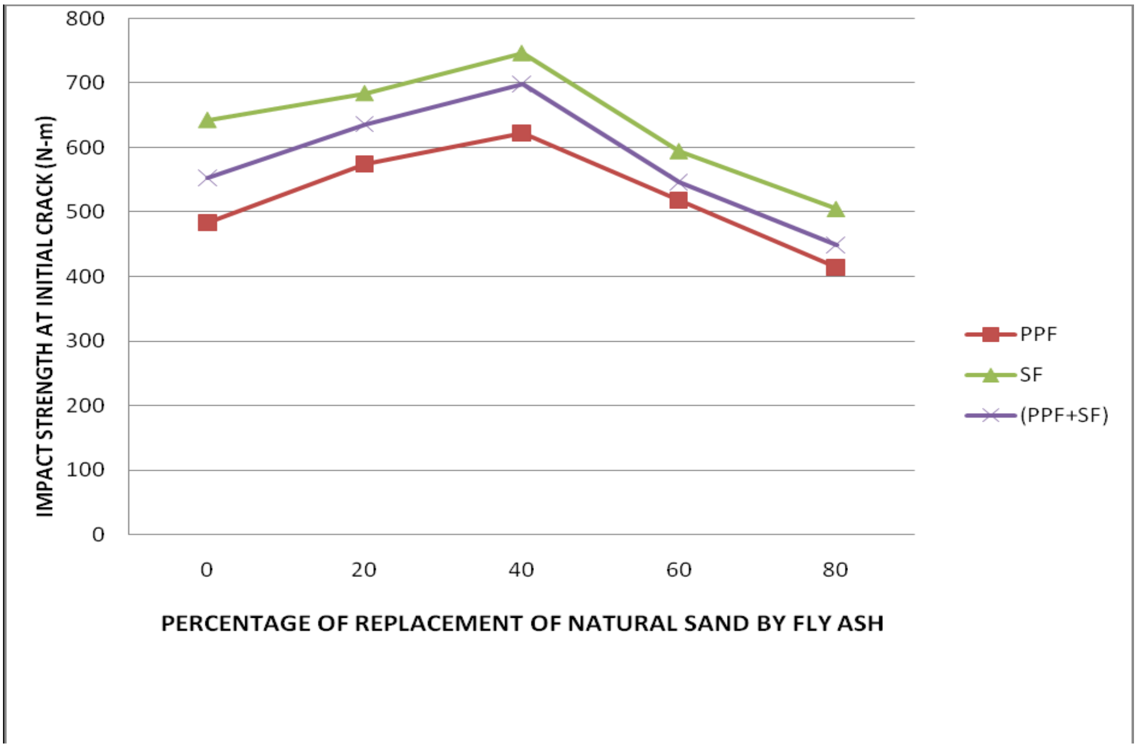

Fig 11 Variation of impact strength at initial crack.

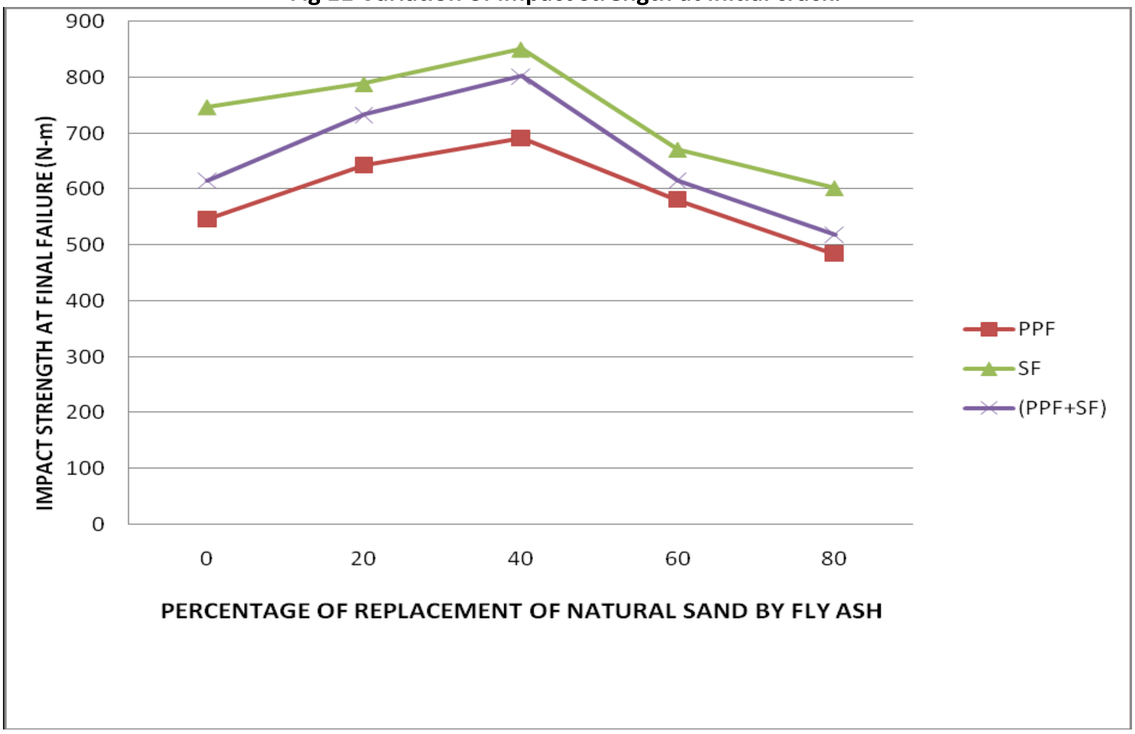

Fig 12 Variation of impact strength at final failure

CONCLUSIONS

The following conclusions may be drawn depending on the experimentation conducted on the effect of partial replacement of natural sand by fly ash on the properties of hybrid fibre reinforced concrete.

1. The workability as measured from slump, compaction factor, Vee Bee degree and percentage flow are higher when 40% of natural sand is replaced by fly ash for monofibre reinforced concrete and also hybrid fibre reinforced concrete.
2. The water absorption and soroptivity values of monofibre reinforced concrete produced with SF or PPF and hybrid fibre reinforced concrete produced with (SF+PPF) are minimum when 40% of natural sand is replaced with fly ash.
3. The compressive or split tensile or flexural or shear or impact strength of monofibre reinforced concrete produced with SF or PPF and hybrid fibre reinforced concrete produced with (SF+PPF) are higher when 40% of natural sand is replaced with fly ash.
4. The compressive or split tensile flexural or shear or impact strength characteristics of hybrid fibre reinforced concrete produced with (SF+PPF) are higher as compared to corresponding monofibre reinforced concrete produced with PPF.

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