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A Study on Strength Properties of High Performance Concrete with Partial Replacement of Cement with Silica Fume and Fine Aggregate with Pond Ash in Concrete

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Abstract : High performance concrete (HPC) is used to fulfill the properties of strength, workability, durability, workability and long life and at the same time pond ash is used to control the solid waste management in the society caused by the coal-fired power plants are major polluters, impacting all spheres of environment -– water, air and land. M60 grade of concrete is used and in which silica fume is partially replaced by 15% instead of cement. To control this solid waste management, pond ash is used as the replacement material in 5%, 10% and 15% for fine aggregate with water cement ratio as 0.32. Strength properties are determined by compressive strength and split tensile strength for 28days.
Key Words : High Performance Concrete, Silica Fume, Pond Ash, Compressive strength, Split tensile strength.

1.0 Introduction:

Concrete: The word concrete means the first point that comes in our mind is use of concrete in construction[1,7]. Now a day's concrete constructed buildings are widely seen in and around the world. In the recent days investigation on properties of concrete should contain high strength, low workability, high durability and long life[6,9]. Meanwhile, construction industries are facing lots and lots of challenges to improve the life of the structure and to prove all the basics properties of concrete. The challenging properties include the strength, durability, energy absorption capacity (for earthquake resistance structures), repair and retrofitting jobs[5]. The concrete which overcomes all these challenges is high performance concrete (HPC). The use of some mineral admixtures and chemical admixtures like silica fume and super plasticizer enhance the properties of high performance concrete.

In the recent days the use of electricity as become the mandatory need and their based power stations as increased to fulfill the basics needs of human being.

The environmental impact of the coal industry includes issues such as land use, waste management, water pollution and air pollution which is caused by the coal mining processing and the use of its products[3-6]. In addition to atmospheric pollution, coal burning produces hundreds of millions of tons of solid waste products which includes fly ash, pond ash bottom ash and flue – gas, desulfurization sludge, that contain mercury, uranium, thorium, arsenic, and other heavy metals. The wet disposal of ash into ash ponds is the most common ash disposal method. The wet method consists of constructing a large "pond" and filling it with fly ash slurry, allowing the water to drain and evaporate from the fly ash over time[4]. Ash ponds are generally formed using a ring embankment to enclose the disposal site. The embankments are designed using similar design parameters

as embankment dams, including zoned construction with clay cores. The design process is primarily focused on handling seepage and ensuring slope stability.

The main aim of my research is to use mineral admixtures (silica fume) (SF) and pond ash (PA) in concrete as the replacement material for cement and fine aggregate. As we all know, the use of mineral admixtures gives the strength to the concrete but indeed the use of pond ash for the replacement of fine aggregate is a rare combination. In this research, silica fume is partially replaced by 15% by the weight of cement and pond ash is replaced in varying proportions as 0%, 5%, 10%, 15% and 20% by weight of fine aggregate. The fresh property of the concrete is determined by slump cone test and hardened concrete properties of the concrete are determined by compressive strength and split tensile test.

2.0 Materials

2.1 Cement:

Ordinary Portland cement of grade 53 conforming to Indian Standard specifications is used. The code referring to Indian Standard specifications is IS 12269.1987 - OPC 53 grade cement.

Physical Properties of Cement

S.No.	Properties	Result
1.	Specific Gravity	3.18
2.	Consistency	28%
3.	Initial Setting Time	35 mins
4.	Fineness	2%

2.2 Silica Fume:

Silica fume is a mineral admixture which is obtained in powder form from ELKEM INDIA Pvt.Ltd., Mumbai. Silica fume is a byproduct from silicon or Ferro – silica industry. The Indian Standard specification conforming to the codal provisions is IS 15388:2003.

Chemical Composition of Silica Fume

Chemical Composition	Silica Fume
Silica di oxide (Sio_2)	93.5
Aluminum oxide (Al_2O_3)	0.06
Ferric Oxide (Fe_2O_3)	0.45
Calcium oxide (CaO)	0.5
Magnesium Oxide (MgO)	0.67
Sulphur trioxide (SO_2)	0.10
Sodium Oxide (Na_2O)	0.32
Potassium Oxide (K_2O)	0.85
Loss on igniting (LOI)	2.26

Physical Properties of Silica Fume

S.No.	Properties	Result
1.	Specific gravity	2.21
2.	Fineness	2.2%

2.3 Fine Aggregate:

Fine aggregate is obtained from the banks of the river and the codal provision of

Indian Standard specification conforming to be IS 383-1970.

Properties of Fine Aggregate

No	Properties	Result
1.	Dry rodded density	1726 kg/ m^3
2.	Fineness modulus	4.03
3.	Specific gravity	2.70
4.	Water absorption	0.7%

2.4 Pond Ash:

Pond ash is obtained from Mettur power plant.

Chemical Composition of Pond Ash

Chemical Composition	Pond Ash
Silica (SiO_2)	58.9
Alumina (Al_2O_3)	25.5
Iron Oxide (Fe_2O_3)	4.1
Lime (CaO)	3.8
Magnesia (MgO)	3.9
Sulphates (SO_3)	0.2
Sodium (Na_2O)	0.5
Potash (K_2O)	0.4

Physical Properties of Pond Ash

S.No	Properties	Result
1.	Fineness Modulus	3.14
2.	Bulk density	1.01 Kg/m^3
3.	Specific Gravity	3.21

2.5 Coarse Aggregate:

The coarse aggregate used for the experimental program is locally procured and testing was done as per IS 383- 1970.

Properties of Coarse Aggregate.

Properties	Result
Sieve analysis	Single sized aggregate - 12.5 mm
Specific gravity	2.75
Dry density	1638 Kg/m3
Water absorption	0.52%
Fineness modulus	2.98
Impact factor	35%

2.6 Super Plasticizer:

It was observed that increase in pond ash content in concrete mixes lead to decrease the slump value of concrete. It could be due to the increase in fine particle of pond ash in concrete mixes lead to increase the surface area of the fine aggregate with constant water cement ratio. To maintain the slump value, polycarboxylic ether based super plasticizer (Sikka viscocrete-10R) of SIKA brand complying with BIS: 9103–1999 was used. Specifications of super plasticizer are given in Table.

Specifications of Super Plasticizer

BASIS	POLYCARBOXYLATE ETHER
Appearance	Brown liquid
Density	1080 g/l at 30°C
P^h value	Approx.5.0
Specific gravity	1.1

2.7 Water:

Potable water is used conforming to IS 456: 2000 is used.

3.0 Mix Promotions

ACI Method ACI 211, 4R- 93

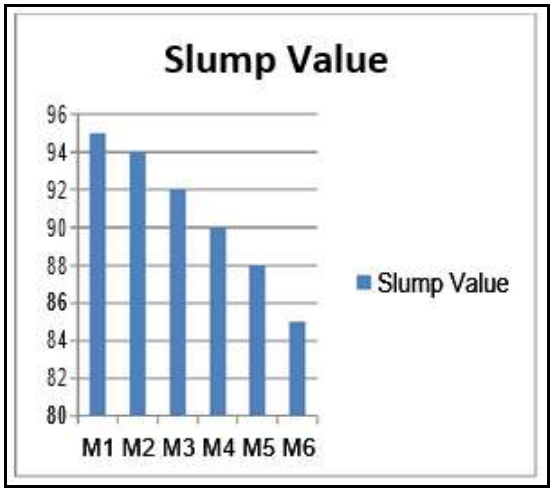
Mix	Cement	SF	SF	FA	PA	PA	CA	Water	SP
	Kg/m^3	%	Kg/m^3	Kg/m^3	%	Kg/m^3	Kg/m^3	Kg/m^3	Kg/m^3
M1	490.10	-	-	712.80	-	-	1113.84	152.91	3.92
M2	416.58	15	73.52	712.80	0	-	1113.84	152.91	3.92
M3	416.58	15	73.52	677.16	5	35.64	1113.84	152.91	3.92
M4	416.58	15	73.52	641.52	10	71.28	1113.84	152.91	3.92
M5	416.58	15	73.52	605.88	15	106.92	1113.84	152.91	3.92
M6	416.58	15	73.52	570.24	20	142.56	1113.84	152.91	3.92

4.0 Test on Fresh Concrete:

4.1 Slump Cone Test:

Workability of concrete is determined by slump one test and which indicates water-cement ratio. The Indian standard specification conforming the codal provisions is IS: 1199 – 1959.

Mix	M1	M2	M3	M4	M5	M6
Slump Value	95	94	92	90	88	85



5.0 Test on Hardened Concrete:

5.1 Compressive Strength:

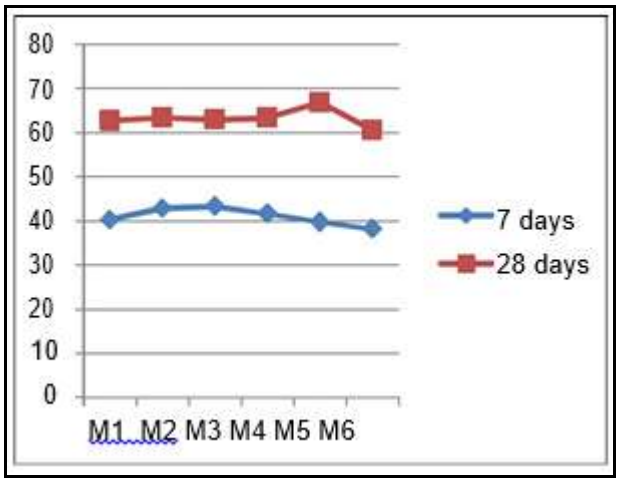
Compressive strength of concrete is carried out in a cube of dimensions

150mm×150mm×150mm. The test is carried out in 7days and 28days as per the Indian Standard specification IS: 516-1959.

In the early stage, at 7days the strength of pond ash compared with the conventional concrete (M2) is reduced but at the 28days testing M5 (15% SF & 15% PA) gives the optimum result.

COMPRESSIVE STRENGTH TEST

Mix	M1	M2	M3	M4	M5	M6
7 Days (N/mm^2)	40.2	42.8	42.3	41.6	39.7	38.1
28 Days (N/mm^2)	62.7	63.4	62.9	63.3	66.8	60.6



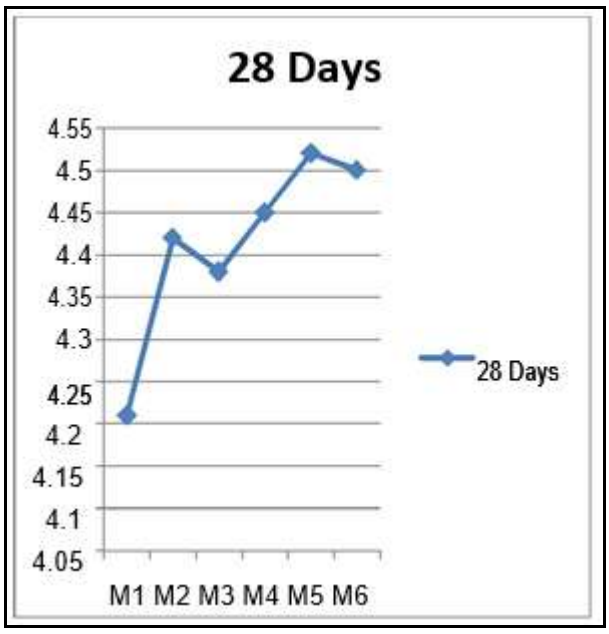
5.2 Split Tensile Strength:

Split tensile strength of concrete is carried out in a cylinder of dimensions 150mm diameter and 300mm height. The test is carried out for 28days as per the Indian Standard specification IS: 5816-1999.

At the 28days testing M5 (15% SF & 15% PA) gives the optimum result.

Split Tensile Strength

Mix	M1	M2	M3	M4	M5	M6
28 Days (N/mm^2)	4.21	4.42	4.38	4.45	4.52	4.50



6.0 Result and Discussion:

1. The initial cost of silica fume is high, but it gives high strength, high durability, low workability, long life.
2. Hence from the above results we conclude that the slump value for different mix proportions decreases when pond ash (PA) is use.
3. The use of mineral admixtures (silica fume) (SF) gives us high strength.
4. At 7 days strength, the mix proportion of silica fume gives high strength than pond ash.

5. Later at 28days test with 15% replacement of silica fume and 15% replacement of pond ash gives us optimum result than conventional concrete.

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