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EFFECT OF PARTIAL REPLACEMENT OF SAND BY POND ASH ON STRENGTH CHARACTERISTICS OF DISCRETE FIBER REINFORCED CONCRETE

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ABSTRACT

Pond ash is wastes and by-products of Thermal power plant, have been introduced into Indian concrete industry to conserve natural resources of ingredients of concrete. In India, most of the Thermal power plants adopt wet method of ash disposal. Pond ash is collected from Thermal power plant at the bottom, in that it contains significant amount of relatively coarser particles (spanning from 150 microns to 2.36 mm). Pond ash utilization helps to reduce the consumption of natural resources. Also it is help to solve the problem of disposal of Pond ash because it contains huge amount of chemical compounds such as SiO_2, Al_2O_3 etc. These chemical compounds (SiO_2, Al_2O_3) are plays an important role in hydration reaction and helps to produce bond between two adjacent particles. Use of Pond Ash in concrete is an important eco efficiency drive. It is necessary to find the exact suitable percentages of pond ash so that it is decided to use in varying percentage as 0%, 10%, 20% and 30% and to check the properties of fresh concrete and hardened concrete such as slump and compressive strength, tensile strength, flexural strength respectively. Also concrete plays an important role in long life period of structure so it is also important to check effect on durability by using sulphate attack, chloride ion penetration, drying shrinkage.

Study shows the basic properties of Pond ash. It also compares these properties with natural sand. Partial replacement does not cause any adverse effect on properties of fresh concrete. The result shows that concrete giving good strength with partial replacement of fine aggregate. As well as Pond ash is the good if used as filler material in concrete. Thus, it is suitable to use pond ash as fine aggregate or partial replacement with natural sand.

1. INTRODUCTION

Use of industrial by-products in concrete will show the way to green environment and such concrete can be called as "Green Concrete". There are various types of industrial wastes which can be considered for usage in concrete. The most commonly used industrial waste to replace sand and cement in concrete are Fly Ash, Rice Husk Ash, Blast Furnace Slag, Pond ash, Red Mud and Phosphor, Gypsum, Silica Fume, Fumed silica, Crushed glass, Eggshells. India depends primarily on coal for the necessity of power and its power generation and it is likely to go up with each passing day. The fly ash generation in Indian Thermal Stations is likely to shoot up to several million tonnes. The dumping of fly ash will be a huge problem to environment, especially when the quantity increases from the present level. Ash is the residue generated after combustion of coal in Thermal Power Plants. Size of the particles of ash varies from 1 micron to 600 microns. The very fine particles (Fly ash) collected from this ash collected by electrostatic precipitators are being used in the manufacture of blended cements. Unused Fly ash and Bottom ash (residue collected at the bottom of furnace) are mixed in slurry form and deposited in ponds which are called as Ash ponds. Hence worldwide research work is focused to find alternative use of this waste material and its use in concrete industry is one of the effective methods of utilization. Increase in demand and decrease in natural resource of fine aggregate for the production of concrete has resulted in the need of identifying a new source of fine aggregate. The possibility of utilization of Thermal Power Plant by-product Pond ash, as replacement to fine aggregate in concrete is taken into consideration.

The use of reinforcement in improving the strength parameters of geo-materials has taken momentum due to the availability of variety of synthetic materials commercially at cheaper rates. The basic principles involved in earth reinforcement techniques are simple and have been used by mankind for centuries. One of the essential characteristics of reinforced soil is that it is made with two types of elements, soil grains and reinforcements. The basic mechanism of reinforced earth involves the generation of frictional forces between the soil and reinforcement. By means of friction the soil transfers the forces developed in earth mass to the

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reinforcement thus developing tension. The earth develops pseudo cohesion in the direction in which reinforcement is placed and the cohesion is proportional to tension developed in reinforcement.

2. CONSTITUENT MATERIALS USED

The constituent materials used are cement, fine aggregate, coarse aggregate, stone dust and water. The recommended materials have been described below.

Cement

Various types of cement can be used in concrete with stone dust. The cement should be fresh, free from foreign matters and of uniform consistency. Usually ordinary Portland cement is used in normal conditions.

Fine Aggregate

The most common fine aggregate used in concrete is sand. The sand should be clean, hard, strong and free from organic impurities and deleterious substances. It should be capable of producing a sufficiently workable mix with a minimum water-cement ratio.

Coarse Aggregate

The aggregates are formed due to natural disintegration of rocks or by artificial crushing of the rock or gravels. The properties of coarse aggregate are chemical and mineral composition, spectrographic description, specific gravity, hardness, strength, physical and chemical stability, pore structure and color. Some other properties of the aggregate not possessed by the parent rocks are particle size and shape, surface texture and absorption etc. All these properties may have a considerable effect on the quality of concrete in fresh and hardened states.

Pond Ash

Pond ash used in this study was collected from Guru Gobind Singh Super Thermal plant, Ropar. The samples were dried at the temperature of 105-110 degrees. The ash sample was screened through 2mm sieve to separate out the foreign and vegetative matters. Then the pond ash samples were stored in airtight container for subsequent use

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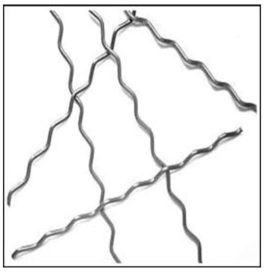
Steel Fibers

Fibres can be used to improve the stability of HyFRSCC, as these help prevent settlement and cracking due to plastic shrinkage of the concrete. Steel fibres are used to modify the ductility/toughness of the hardened concrete. Recron fibres are used to minimize the minor cracks. Their length and quantity is selected depending on the maximum size of aggregate and on structural requirements. If they are used as a substitute for normal reinforcement, the risk of blockage is no longer applicable but it should be emphasized that using HyFRSCC in structures with normal reinforcement significantly increases the risk of blockage. Discrete steel fibres conforming to ASTM A 820/A 820M-04 were used. They were Type 1 cold-drawn, wire-grooved shown in Fig. The steel fibres had a length (lf) of 50mm and a diameter (df) of 1 mm. Hence, their aspect ratio was 50. The tensile strength of the fibre was found to be 1098 MPa using tensometer. Fibre content was varied as 0%, 0.5%, 1% and 2% by volume of concrete.

Steel Fiber mixtue



Steel Fiber Detailed

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3. MIX DESIGN

Workability measurements based on the slump value were carried out on fresh fibre-reinforced pond ash concrete. The mix designation and the results of the slump values are presented. Fresh concretes containing 10%, 20% and 30% pond ash as cement replacement in mass basis were prepared by modifying the reference Portland cement concrete. Similarly, fresh fibre reinforced concretes containing 0.5%, 1.0% and 2.0% steel fibre in volume basis were also prepared. The specimens were named as A1, A2, etc. to indicate different pond ash contents and fibre contents. Mixture design was made in accordance with the Indian Standard Code 10262-2009.

Mix proportion of concrete mix

Ingredients	Cement kg/m^3	Fine Aggregates(FA) kg/m3	Pond Ash(PA) kg/m^3	Coarse Aggregates 12.5 kg/m^3	Coarse Aggrgates 20 mm kg/m^3
0% Pond Ash	408.22	668.54	0.00	412	765
10% Pond Ash	384.22	645.25	42.12	408	752
20% Pond Ash	320.24	632.12	84.36	387	739
30% Pond Ash	291.21	629.56	126.20	391	736
20% Pond Ash	320.24	632.12	84.36	387	739

Various mix designation

Mixture No.	Pond Ash Content (%)	Steel Fiber Content (%)	Mixture No.	Pond Ash Content (%)	Steel Fiber Content (%)
A1	0	0	C1	20	0
A2	0	0.5	C2	20	0.5
A3	0	1	C3	20	1
A4	0	2	C4	20	2
B1	10	0	D1	30	0
B2	10	0.5	D2	30	0.5
B3	10	1	D3	30	1
B4	10	2	D4	30	2

4. RESULT ANAYLSIS

- **Determination of Grain Size Distribution:** For determination of grain size distribution, the pond ash was passed through test sieve having an opening size 75µ. Sieve analysis was conducted for coarser particles as per IS: 2720 part (IV), 1975 and hydrometer analysis was conducted for finer particles as per IS: 2720 part (IV). The percentage of pond ash passing through 75µ sieve was found to be 34.2%. Hence the particle size of pond ash ranges from fine sand to silt size. Coefficient of uniformity (Cu) and coefficient of curvature (Cc) for pond ash was found to be 2.17 & 1.24 respectively, indicating uniform gradation of samples. The grain size distribution curve of pond ash is presented in Fig.

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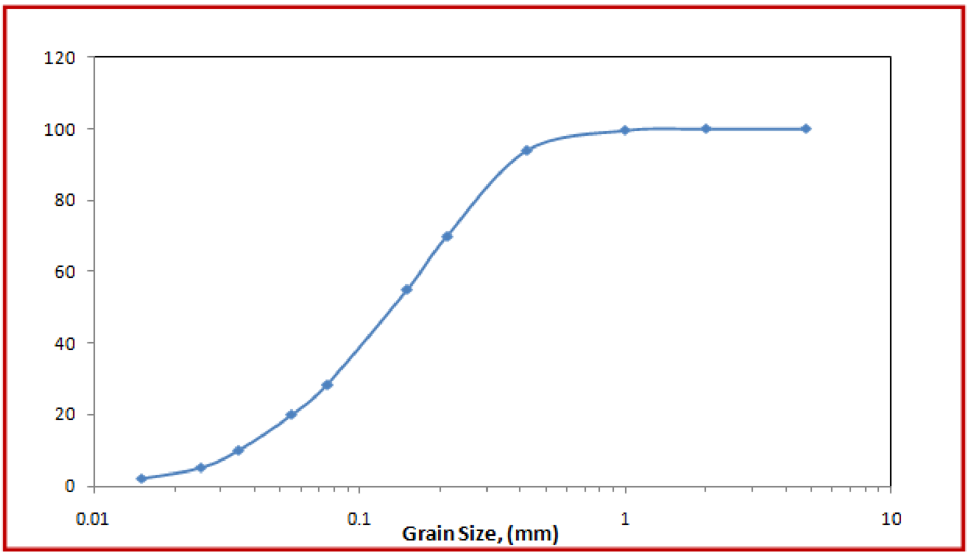

- **Slump Value**

Slump value in mm

Mixture No.	Slump Value	Mixture No.	Slump Value
A1	27	C1	25
A2	28	C2	27
A3	29	C3	28
A4	25	C4	29.5
B1	26	D1	30
B2	27.5	D2	28
B3	29	D3	31
B4	26.5	D4	30

- **Compressive Strength Test:** Compressive strength of the specimens (100 mm×100 mm×100 mm) was determined under compression testing machine. The bearing surfaces of the testing machine were wiped clean and the specimen was placed in the machine in such a manner that the load was applied to the opposite sides of the cubes as cast, and not to the top and bottom faces. The load was applied without any shock or vibration and increased continuously at a rate of approximately 14 N/mm2/min until the specimen failed. The failure load was recorded. The compressive strength of the specimen was calculated by dividing the failure load by the cross-sectional area of the specimen. Compressive strength of the cubes was determined at curing periods of 7 days, 14 days and 28 days

Compressive Strength Test results

Mixture No.	Compressive strength (N/mm^2)			Elastic modulus (GPa)
	7 Days	14 Days	28 Days	28 Days
A1	35.30	34.85	37.85	19.25
A2	30.82	31.95	35.52	15.47
A3	36.21	36.52	39.55	14.95

A4	35.21	35.78	38.45	16.25
B1	30.56	31.95	37.52	18.52
B2	32.52	32.65	36.58	15.98
B3	25.97	28.88	38.54	19.88
B4	22.98	24.85	37.12	15.56
C1	25.96	28.65	36.54	19.21
C2	27.56	27.14	37.10	21.52
C3	26.34	29.57	36.85	18.89
C4	24.65	26.54	38.14	16.22
D1	27.85	29.56	34.95	11.98
D2	25.46	27.28	35.25	12.25
D3	27.98	28.59	33.98	14.12
D4	26.58	29.58	36.58	15.23

- **Split Tensile Test:** The cylindrical specimens were 200 mm in height and 100 mm in diameter. The split tensile strength was also determined at the curing periods of 7 days, 14 days and 28 days. Diametric lines on each end of the cylinder were drawn and it was ensured that they were in the same axial plane. One of the plywood strips along the centre of the lower bearing block was centred and the specimen placed on the plywood strip was aligned so that the lines marked on the ends of the specimen were vertical and centred over the plywood strip. A second plywood strip was placed lengthwise on the cylinder and centred on the lines marked on the ends of the cylinder. Load was continuously applied at a constant rate within the range 0.7–1.4 MPa/min until the specimen failed. The failure load was recorded. The type of the failure and the appearance of the concrete were noted. The split tensile strength (T) was determined from the equation

  $T=2P/\pi ld$, where P is the failure load.

Split Tensile Strength Test results

Mixture No.	Split Tensile strength (N/mm^2)		
	7 Days	**14 Days**	**28 Days**
A1	2.55	2.68	2.60
A2	2.82	2.52	2.71
A3	2.62	2.48	2.83
A4	2.42	2.71	2.88
B1	2.05	2.31	2.32
B2	2.32	2.42	2.52
B3	2.48	2.72	2.63
B4	2.68	2.63	2.66
C1	1.98	2.35	2.41
C2	2.10	2.63	2.59
C3	2.31	2.51	2.69
C4	2.11	2.67	2.72
D1	1.78	2.22	2.25
D2	2.09	2.31	2.43
D3	2.13	2.32	2.62
D4	2.50	2.53	2.71

- **Flexural Strength Test:** Flexural strength of the concrete prisms was determined as per the ASTM C293 [28]. The dimensions of the prisms were 500 mm×100 mm×100 mm. As already mentioned, flexural strength was determined for the curing periods of 7 days, 14 days and 28 days. The load was

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applied without any shock or vibration and was increased continuously at such a rate that the extreme fibre stress increased at approximately 0.7 N/mm2/min. The load was increased until the specimen failed, and the failure load was recorded. The appearance of the fractured faces of concrete and any unusual features in the type of failure were noted.

The flexural strength of the specimen was determined from the expression,

$F_{b=}$pl/bd2 where f_b = modulus of rupture

Flexural Strength Test results

Mixture No.	Flexural strength (N/mm^2)		
	7 Days	14 Days	28 Days
A1	5.12	5.30	7.12
A2	5.02	4.98	6.58
A3	5.36	5.23	7.08
A4	5.86	6.32	8.31
B1	4.65	4.93	5.42
B2	4.85	4.81	5.42
B3	5.10	5.24	6.51
B4	5.32	5.62	6.32
C1	4.92	6.01	5.78
C2	4.98	5.12	6.03
C3	5.23	5.23	6.95
C4	5.87	5.92	7.98
D1	4.85	5.93	6.32
D2	5.36	5.68	6.4
D3	5.62	5.97	6.15
D4	6.05	6.58	8.10

5. CONCLUSIONS

A series of laboratory experiments was conducted to find compressive strength, split tensile strength, and flexural strength of fibre-reinforced pond ash modified concrete. The effect of pond ash content, fibre content and curing period was studied. The following are the conclusions that can be drawn from the experimental investigation:

- The average compressive strength of concrete respectively increased by 5% and 4% when fibre content increased from 0% to 2% for pond ash contents of 0% and 10%. For a
- pond ash content of 20%, the average compressive strength increased by 7% when fibre content increased from 0% to 2%. The average compressive strength increased for 20%
- pond ash content and 0.5% steel fibre content in comparison with 0% pond ash and 0.5% steel fibre. The increase in compressive strength was about 6%. Therefore, only a small increase in compressive strength was achieved with increase in fibre content. Further, when pond ash content increased from 20% to 30%, the average compressive strength decreased for all fibre contents.
- The increase in split tensile strength was about 12% when fibre content increased from 0% to 2% for plain concrete for a curing period of 28 days. When fibre content increased
- from 0% to 2% for a pond ash content of 20%, the average split tensile strength increased by about 17%. Further, for a pond ash content of 30%, the average split tensile strength increased to 22% when fibre content increased from 0% to 2%. Addition of steel fibre improved the split tensile strength of concrete when compared with plain concrete.
- When fibre content increased from 0% to 2% at 0% pond ash, the average flexural strength increased to 20% for a curing period of 28 days. For pond ash contents of 10% and 20%, the increase in flexural strength was respectively 18% and 38% when fibre content increased from 0% to 2%. Further, for a

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pond ash content of 30%, the increase in flexural strength was about 31% when fibre content increased from 0% to 2%.

- The modulus of elasticity decreased by 6%, when fibre content increased from 0% to 2% for plain concrete. Further, for a pond ash content of 10% and 20%, the modulus of elasticity reduced by 24% and 17% respectively when fibre content increased from 0% to 2%. There was a marginal increase of about 12% for a pond ash content of 30%, when the fibre content increased from 0% to 30%. But it cannot be concluded that modulus of elasticity increased when pond ash content increased, since the elastic modulus decreased by 5%, 0.7% and 47% for pond ash contents of 10%, 20% and 30% when compared with 0% fibre content concrete specimens. From the data on elastic modulus, it can be concluded that 20% pond ash can be effectively used as a replacement of cement in concrete.
- Hence, pond ash which is a waste material available abundantly can be effectively utilized as a replacement of cement in concrete, in combination with steel fibres to increase the long term strength of concrete

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