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Performance Enhancement of Fine Fly Ash and Pond Ash Material in Self Compacted Concrete

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***Abstract*— Due to increase in the growth of industrial sectors the power requirement of the country is rapidly increasing. India depends on Thermal Power as its main source, thus there is increase in power requirement every year. Present scenario of our country shows 75 % of country's total installed power generation is thermal of which coal-based generation is 90%. The coal reserves of the country are predominately of lower grades (average of 35% ash content), non-cooking and as a result more than 110 million MT coal ash is being generated every year. Ash generation may likely reach to 170 million MT by 2012. Use of coal brings huge amount of ash every year.**

Research related to new and innovative use of waste materials is being undertaken worldwide. Properties of materials include strength, hardness, density, resistance to corrosion, etc. Materials in industrial wastage has properties like unit weight, specific gravity, shrinkage, absorption, resistance to freezing, etc. The industrial waste material is a bye-product of construction industries and other industries and their wastes are fly ash, pond ash, marble dust, store dust, slag and many more. In this research study modifications in normal concrete materials such as cement aggregate and sand were carried out. Properties of concrete were replaced by fly ash and pond ash. The construction waste material which gives better performance in special concrete was identified. Fly ash and pond ash materials were selected which simultaneously replaces the cement and sand of the special concrete and better results were obtained related to the properties of concrete.

***Index Terms*— Strength, Special Concrete, Properties, Stability, Durability, Fly ash, Pond Ash, Admixture, Waste material.**

I. INTRODUCTION

Concrete is a most widely used construction material today. Flexibility, moulding ability of concrete material, its high compressive strength and the steel reinforcing and pre-stressing technique in concrete facilitates to improve its strength as against its low tensile strength property and contributed largely for its wide spread use. Use of various fibre materials mixed with concrete is also an option to improve performance of the concrete. Various alternatives of improving performance of concrete are leading towards increasing the cost of concrete [7]. To economize the cost of concrete, use of ground granulated blast furnace slag, ricehusk, fly ash, pond ash etc. have already been tried by many researchers as a partial replacement of cement in concrete mix [6].

In India the power stations are mostly coal based which requires a huge amount of coal. Present scenario of India shows 75% of country's total installed power generation is thermal of which coal-based generation is

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90%. About more than 100 thermal power plants whose power generation capacity 1,70,000 MW & coal consumption for this is nearly 350 million MT every year[12]. As the combustion of coal it produces a large amount of fly ash.(Average of 35% of coal) near 125 million MT coal ash is being generated every year[18].Fly ash is the side-effect of thermal power station which requires a huge zone, reasonable strategy for its transfer[2]. Fly ash is gathered by mechanical or electrostatic precipitators from the pipe gases of power plant while; base ash is gathered from the base of the boilers [4].

Fly ash is a coal ignition item that is made out of the particulates (fine particles of fuel) that are driven out of coal-terminated boilers together with the pipe gases. Ash that tumbles to the base of the kettle is called base ash. In present day coal-terminated power plants, fly ash is by and large caught by electrostatic precipitators or other molecule filtration gear before the pipe gases come to the stacks. Together with base ash expelled from the base of the evaporator, it is known as coal ash. Contingent on the source and cosmetics of the coal being scorched, the parts of fly ash change impressively [1]. Fly ash includes considerable amounts of aluminium oxide (Al2O3), calcium oxide (CaO) and silicon dioxide (SiO2) [3].

Pond ash is one such elective material which can be viably used to supplant the normal material. At the point when coal is scorched for the most part fly ash and base ash is delivered. The fly ash is gathered by Electrostatic precipitator process [5]. The ash which falls at the base of heater is blended with water, and afterward it is diverted from plant through funnels lastly dumped on open land [6]. After vanishing whatever ash remains is called pond ash [14]. The usage of lake slag obliged by specific and other stress, in helper concrete anyway it might be supportively used in geotechnical and throughfare advancements, mass strong improvement, earth fill, engaging the use of epic proportion of lake fiery debris delivered from warm power station.

The exchange of fly slag and lake powder is a noteworthy test to all as stressed to their sum which is growing bit by bit. Subsequently overall examination was performed to discover elective utilization of this waste material and its utilization in concrete as a fractional substitution of bond and fine total is one of the compelling strategies for use [16]. The likelihood of usage of warm power plant by item for example fly ash and pond ash as substitution to bond and fine total individually in cement is thought about [15].

In this examination, an endeavour has been made to consider the techno-monetary investigation for the compressive strength of Self compacted concrete. The fly ash is acquired from a Thermal Power Plant. This plant is situated in Maharashtra state. The plant is a foundation of 1968[8]. It has an generation limit of 480 MW. It expends 7500-8500 MT/day of coal and creates 2550 to 2800 MT/day fly ash [7]. Here, in our work a relative investigation of the attributes compressive quality between Ordinary Portland Cement concrete and Fly ash based cement has been made [4]. Fly ash is utilized in different extents going from 10% to half by weight of concrete in ventures of 5%. Utilizing the experimental information, a column section is structured [3].

II. Global Scenario

Fly ash in developed countries is generally used for brick manufacturing, road construction, land filling, dam construction, agriculture etc. In global context it has been seen that countries like Italy, Denmark and Netherlands have annual fly ash generation of 2 MT and have 100% utilization of the same. Whereas, USA, Germany, which produce more fly ash (10-75 MT/Year) utilize around 50-85% of fly ash produced. Major application of fly ash in these countries are in cement, concrete, mine fill and bricks manufacturing etc [15]. Fly ash generated in India (112 MT/year) and China (100 MT/year) is utilized only up to 38% and 45% respectively [13]. In Poland and Germany, bulk quantity of fly ash is used for mine filling, cement and concrete production [15].

III. Indian Scenario

Generation of energy has been increasing at a very fast rate due to high growth of industrialization and urbanization. At present, India produces around 125 million ton of fly ash annually. In the installed power generation capacity of 170000 MW, 64% comes from thermal power, 24.7% from hydropower, 2.9% from nuclear and 7.7% from renewable energy sources [13]. Coal alone contributes around 82% of the total power produced from thermal sources. Indian coal contains around 35% to 45% of ash content [11]. It is estimated that about 65000 acres of land of India is occupied by ash. This is a particularly important concern for India as India currently produces over 125 million of fly ash annually[12]. Disposal of fly ash is a growing difficulty in India. One acre land is required for every MW of power generated for ash disposal. Huge

amount of water is also required for fly ash disposal in slurry form. The concerned authorities have already started taking positive steps in the utilization of fly ash in construction such as mandating the use of fly ash in road and building construction projects within a 100 km [8]. Radius of acoal fired power plants. They have also made it mandatory for every construction agency engaged in construction of buildings with in radius of 100 km from a coal or lignite based thermal plants to use clay bricks tiles and blocks made up of fly ash[16]. Ash generated in thermal power plants is classified as a bottom ash and fly ash. In thermal power plants, pulverized coal is blown into a burning chamber where it ignites to heat the boiler tubes and leaves behind ash [14]. Heavier ash particles fall to the bottom of furnace and are known as 'bottom ash'. The lighter particles are fine enough to be carried away suspended in the exhaust gases and hence they are called as 'fly ash'. Blended cement not only enhances the life of concrete roads by protecting them from chloride and sulphate attack, but also reduces thermal cracking, plastic and drying shrinkages that are common with ordinary Portland cement constructions [7]. One of the advantages of the concrete roads is the lower lifecycle cost compared to bituminous road [5]. Bitumen, a by-product from petroleum crude processing is supplied globally and its price has been rising. Nearly 70% of India's petroleum crude is imported [7]. The demand for bitumen in the coming years is likely to grow compared to its availability [6]. Therefore it may be in the interest of construction industry to explore alternative binder material for road construction.

IV. Problem Formulation

The purpose of this study is to evaluate the effect of fly ash and pond ash as a partial replacement to cement and fine aggregate respectively on the strength and durability of concrete samples.

V. Material List

Ordinary Portland Cement (OPC) 53 grade confirming to IS12269:1987.

A. Cement

Ordinary Portland Cement 53 grade conforming to IS: 8112-1939 was used. Its properties are shown in Table I.

B. Sand

Locally available river sand confirming to IS 383:1970 with fineness modulus of 3.2 and specific gravity of 2.7 was used.

C. Fly ash

Fly ash sample was collected from a Thermal Power Plant station situated Gujarat state. Fly ash confirmed to low calcium ash (Class F) as per IS 3812 -2008. The chemical properties of fly ash are given in Table II.

D. Pond Ash

Pond ash sample was also collected from a Thermal Power Plant Station. Its sieve analysis is given in Table III.

E. Coarse Aggregates

Crushed 20 mm aggregate had negligible water absorption and had specific gravity of 2.78. The overall grading requirement of coarse aggregate is as per IS: 383-1970. Table IV presents physical properties of fly ash.

TABLE I. PROPERTIES OF CEMENT

Sr no.	Characters	As per IS: 8112-1939
1	Specific Gravity	3.15
2	Initial Setting Time	>30 min
3	Final Setting Time	<600 min
4	Fineness of cement	10%
5	Compressive Strength 3 days 7 days 28 days	 >23 N/mm^2 >33 N/mm^2 >53 N/mm^2

TABLE II. CHEMICAL PROPERTIES OF FLY ASH

Sr no.	Description	%
1	Silica (Sio2)	64.43
2	Aluminium (AI203)	20.67
3	Iron oxide (Fe203)	6.00
4	Calcium oxide (CaO)	1.25
5	Magnesium oxide(MgO)	0.80

TABLE III. PHYSICAL PROPERTIES OF FLY ASH

Sr no.	**Element**	**Content**
1	Fineness-passing 45 µm (%)	40.0
2	Specific gravity	18.0

TABLE IV. PHYSICAL PROPERTIES OF FLY ASH

Sieve size	10 mm	4.75mm	2.56mm	1.18mm	600 micros	300 micros	150 micros
Passing (%)	100	100	100	100	100	81.2	53.2
I.S. limit	100	90-100	60-95	30-70	15-34	20-5	0-10

VI. MIX PROPORTIONS

M40 grade concrete was used for the laboratory investigation as M30 to M40 grade concrete is being used in high rise towers in foundation work to stand against aggressive condition. The mix design for OPC concrete was confirming to IS 10262: 2009. Then fly ash was used as partial replacement of cement by 10% using modified replacement method. Pond ash was used as partial replacement of river sand in control mix by 16%, 22% and 28%. Again in fly ash mix concrete pond ash was used as partial replacement to river sand by 16%, 22% and 28%. The curing was carried out for 3, 7 and 28 days for compressive strength determination. Table V gives mix proportion of concrete employed in the research study. Physical properties of fly ash are shown in Table VI.

TABLE V. MIX PROPORTION OF CONCRETE

Sr No.	**Material**	**Quantity**
1	Cement – OPC 53	416.64 kg/m^3
2	Mineral Admixture (not used)	0.00 kg/m^3
3	Water	229.18 kg/m^3
4	Fine Aggregate	731.49 kg/m^3
5	Coarse Aggregate	1149.05 kg/m^3
6	Chemical Admixture(super plasticizer)	20.9 ml/m^3
7	Water-Cement Ratio	0.500

TABLE VI. PHYSICAL PROPERTIES OF FLY ASH

Concrete types	Cement (kg/m^3)	Fly ash (kg/m^3)	Fine Aggregate (kg/m^3)	Pond ash (kg/m^3)	Coarse Aggregate (kg/m^3)	Water (litre/m^3)	Chemical Admixture (ml/ $m^{3)}$
Normal concrete	333.31	-	731.49	-	1149.05	229.18	20.9
Concrete with 20% fly ash and 16% pond ash	333.31	83.32	614.45	117.03	1149.05	229.18	20.9
Concrete with 20% fly ash and 22% pond ash	333.31	83.32	570.56	160.9	1149.05	229.18	20.9
Concrete with 20% fly ash and 28% pond ash	333.31	83.32	526.67	204.8	1149.05	229.18	20.9

VII. RESULT

F. Compressive Strength of Concrete is shown in Table VII.
Dimension of cube: - 150 mm × 150 mm × 150 mm
Area of cube: - 0.025 m^2

TABLE VII. COMPRESSIVE STRENGTH OF CONCRETE

Concrete type	Compressive strength -N/mm^2		
	3 day	7 day	28 day
Normal concrete	19.4	28.14	48.15
Concrete with 20% fly ash and 16% pond ash	20.68	28.46	45.16
Concrete with 20% fly ash and 22% pond ash	18.74	25.98	41.40
Concrete with 20% fly ash and 28% pond ash	15.81	22.20	35.90

Figure 1 exhibits compressive strength of concrete cube.

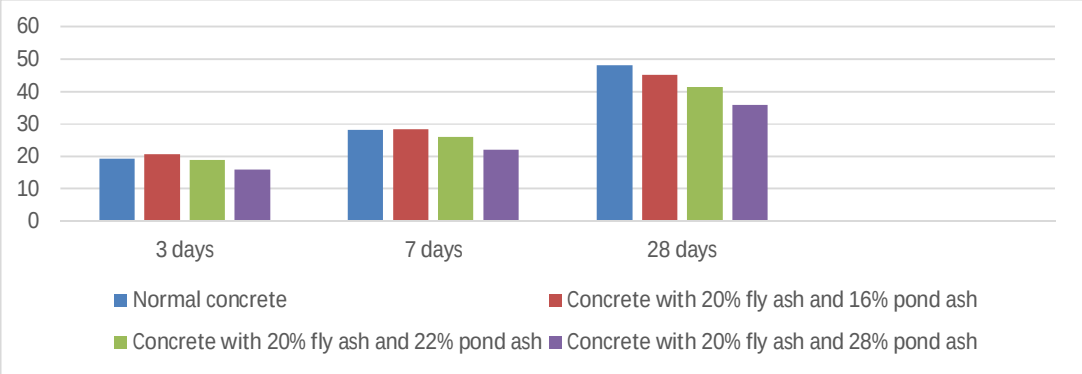

Figure 1. Graph of compressive strength of concrete cube

G. Tensile Strength of Concrete Cylinders
Table VIII shows tensile strength of concrete cylinders.

TABLE VIII. TENSILE STRENGTH OF CONCRETE CYLINDERS

Mix Proportions	**Tensile strength -N/mm2**		
	7 day	**28 day**	**Minimum Limit**
Normal concrete	2.95	3.82	5.42
Concrete with 20% fly ash and 16% pond ash	3.14	4.15	5.42
Concrete with 20% fly ash and 22% pond ash	2.84	3.52	5.42
Concrete with 20% fly ash and 28% pond ash	2.11	2.95	5.42

Figure 2 illustrates tensile strength of concrete cylinders.

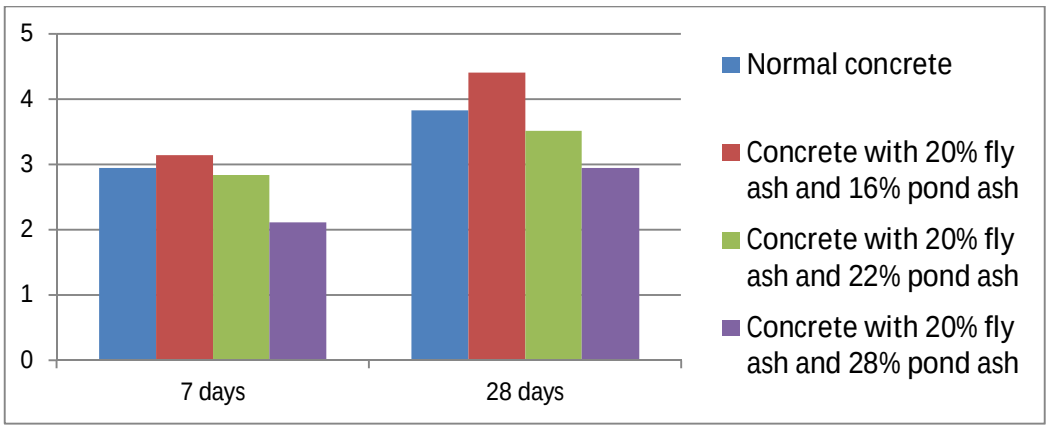

Figure 2. Graph of tensile strength of concrete cylinders

H. Flexural Strength of Concrete Beam

Table IX shows flexural strength of concrete beam.

TABLE IX. FLEXURAL STRENGTH OF CONCRETE BEAM

Mix Proportions	Tensile strength -N/mm2		
	7 day	28 day	Minimum Limit
Normal concrete	4.10	6.92	5.42
Concrete with 20% fly ash and 16% pond ash	4.75	7.40	5.42
Concrete with 20% fly ash and 22% pond ash	4.44	6.98	5.42
Concrete with 20% fly ash and 28% pond ash	3.22	5.21	5.42

Figure 3 shows flexural strength of concrete beam.

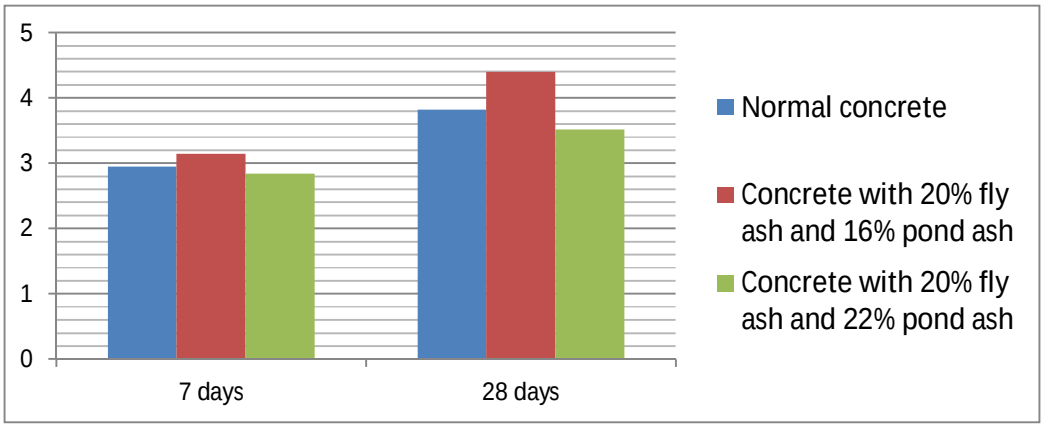

Figure 3. Graph of flexural strength of concrete beam

VIII. CONCLUSION

Following results with reference to compressive strength, tensile strength, flexural strength and workability were obtained:

I. Compressive Strength

- Highest strength was obtained for using 20% fly ash as cement replacement and 16% pond ash as replacement as fine aggregate.
- Compressive strength of 20.68 Mpa was obtained at 3 days, 28.46 Mpa at 7 days and 45.16Mpa at 28 days for self-curing sample.

J. Tensile Strength

- Splitting tensile strength of 3.14 Mpa was obtained for using 20% fly ash as cement replacement and 16% pond ash as replacement as fine aggregate.at 7 days
- Splitting tensile strength of 4.15Mpa was obtained for using 20% fly ash as cement replacement and 16% pond ash as replacement as fine aggregate.at 28 days
- The split tensile strength of cylinder we concluded that we are not getting tensile strength up to desire limit of 5.42 Mpa.

K. Flexural Strength

- Flexural strength of 4.75 Mpa was obtained for using 20% fly ash as cement replacement and 16% pond ash as replacement as fine aggregate at 7 days
- Flexural strength of 7.40 Mpa was obtained for using 20% fly ash as cement replacement and 16% pond ash as replacement as fine aggregateat at 28days
- The flexural strength of beam we concluded that we are not getting flexural strength up to desire limit of 5.42 Mpa.

L. Workability

- Positive result was obtained in the workability test performance.
- 680 mm flow diameter of the concrete was obtained in the normal self compacting concrete.
- When we go for the change of the proportion of material and cementanius material, actual flow of concrete is increased with increase of proportion of pond ash change with fine aggregate. So, actually we get good workability of concrete as compare to normal self-compacting concrete.

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