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EXPERIMENTAL INVESTIGATION ON UTILIZATION OF FLY ASH AND POND ASH WITH SELF COMPACTING CONCRETE

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Abstract— Self Compacting Concrete (SCC) is a flowing concrete mixture that is able to consolidate under its own weight, without the need for vibration. The highly fluid nature of SCC makes it ideal for placing in difficult conditions and in sections with congested reinforcement.

Mixture proportions for SCC differ from those of ordinary concrete, in that the former has more powder content and less coarse aggregate. Supplementary cementitious materials such as fly ash, silica fume and blast furnace slag, pond ash are normally used as powders to enhance the technology of SCC.

In addition, SCC also incorporates chemical admixtures, such as HRWR (High Range Water Reducer), and VMA (Viscosity Modifying Agent). Large amount of fly ash and pond ash is being generated in India annually and hence there is a strong need to use this byproduct from thermal power stations, in large proportions in concrete which is also makes the concrete as cost effective. A SCC mix was arrived based on available EFNAARC guide lines and using various mix combinations. An experimental study is made on the properties of SCC incorporating fly ash and pond ash. Slump flow test, V-funnel test, L-box test were carried out to confirm the self-compact ability of concrete. Compressive strength test, split tensile test, flexural strength test, young's modulus test were carried out on SCC. This experimental investigation studies the potential of using Pond ash from Thermal Power Plant, as a part replacement with sand in plaster mortar. Workability of mortar mix is increased due to addition of pond ash, which will result in the reduced w/c ratio. Change in the volume of hardened mortar is very less due to addition of pond ash, which results less occurrence of surface cracks.

INTRODUCTION

1.1 GENERAL

Pond ash is the waste product from most of the thermal power plants in India. The fly ash gets mixed with bottom ash and disposed of in large pond dykes as slurry. Pond ash contains relatively coarse particles. The huge amount of pond ash accumulated around the thermal power stations is still posing threat to environment. The utilization of pond ash as a building material is one of the possible way of its sustainable management. In the present study, an attempt is made to ascertain the possibility of using the pond ash as a replacement of sand in plaster mortar.

1.1.1 Origin of Pond Ash

Pond ash is the waste product from most of thermal power plants in India. The fly ash gets mixed with bottom ash and disposed of in large pond or dykes as slurry. Pond ash contains relatively coarse particles. As Pond ash is being produced at an alarming rate, efforts are required to safely dispose it and if possible find ways of utilizing it.

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Fig 1.1 Pond Ash Sample.

1.1.2 Necessity of Pond Ash Management

It is estimated that by the end of tenth planned period an additional 124000 Mega Watt (MW) of power sector expansion will require in India to meet the raising demands of energy.

So the quantum of Pond ash generation will increase in future. It has warranted the scientific as well as industrial community to initiates research and development work for finding innovative use and safe disposal of Pond ash so that instead of a waste product, the pond ash can be utilized in large quantities in various engineering works.

The ash produced in thermal power plants can cause all three environmental risks - air, surface water and ground water pollution. Air pollution is caused by direct emissions of toxic gases from the power plants as well as windblown ash dust from ash ponds.

The air borne dust can fall in surface water system or soil and may contaminate the water/soil system. The wet system of disposal in most power plants causes discharge of particulate of ash directly into the nearby surface water system.

1.1.3 Sources of Pond Ash in India

In India as coal based Thermal Power Plant has contributes to 75% to the total power generation. The coal reserves of the country is predominately of lower grade of non-cooking and as a result the quantity of ash produced will also increase. The Indian coal on an average has 35% ash and this is one of the prime factors which lead to increase ash production. Hence, ash utilization is a problem for the country.

The Indian Thermal power plant uses high ash and inferior quality non-cooking coal. Present India's Thermal installed capacity to an estimate is 1, 00,000 MW and coal consumption for Thermal power generation required is 300 million MT every year. Use of coal brings many problems, primarily due to huge amount of ash, which is produced by-product of the process of power generation. Out of total ash produced, fly ash contributes to small percentage, majority being pond ash and bottom ash.

Fig 1.2 Pond ash manufacturing plant

1.1.4 Environmental Consideration

The ash produced in thermal power plants can cause all three environmental risks - air, surface water and ground water pollution. Air pollution is caused by direct emissions of toxic gases from the power plants as well as windblown ash dust from ash ponds. The air borne dust can fall in surface water system or soil and may contaminate the water/soil system. The wet system of disposal in most power plants causes discharge of particulate of ash directly into the nearby surface water system.

1.2 EXISTING USE OF POND ASH

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The literature available specifically on the use of pond ash is scarce. However in general the fly ash has lot of potential for its sustainable use. The use of fly ash in the construction of road and embankment has been successfully demonstrated in the country. The Ministry of Surface Transport (MOST) and Central Public Works Department (CPWD) have accepted the use of fly ash and have executed many projects. The fly ash can be utilized in cement concrete and mortar as an ingredient / partial replacement of cement and sand. The replacement of OPC may vary from 15 to 35 % or even higher percentage in mass concrete. BIS: 456 The pond ash is also utilized in manufacturing of Light Weight Aerated Concrete (LWAC) products such as blocks, panels, reinforced slab, etc, which are much lighter than conventional materials. The bulk density of product ranges from 500kg/cum to 1800kg/cum, depending upon reinforcement. The use of block in housing construction can results nearly40 % reduction in dead weight, 50 % saving in construction time and about 80 % saving in consumption of mortar in comparison to conventional brick work.

The fly ash (90-95%) mixed with OPC (5-10%), along with the water make the flow able fill material termed as Controlled Low Strength Material (CLSM), which can use in the restricted areas where placing and compaction is very difficult such as narrow trenches, utilities structure like mines, tunnels, tanks and trenches in road pavement cut. The use of pond ash in mine fill material is one of the possible alternatives to be considered by various agencies. The optimum utilization of pond ash through mine void filling by High Concentrated Slurry Disposal (HSDS) system may prove a plausible solution of pond ash management. The use of fly ash in agriculture applications has been well demonstrated and is gaining momentum in the agriculture sector of country. This is picking up in Karnataka, West Bengal and Madhya Pradesh and for wasteland reclamation in Uttar Pradesh.

1.2.1Use of pond ash

Pond ash/Fly ash can is used for multifarious applications. Some of the application areas are the following:

- Lime – Fly ash Soil Stabilizing in Pavement and Sub-base
- In Soil Conditioning
- Manufacture of Bricks
- Part replacement in mortar and concrete.
- Stowing materials for mines.

1.2.2 Advantages of Pond Ash concrete

By using pond ash in cement concrete, we can reduce the cost of concrete without compromising the strength

This concrete is more useful in the areas were the cost of sand is expensive By utilizing dumped pond ash by protect hectors of land from degradation Compressive strength is high compared to conventional mix.

1.2.3 Effect of fly ash on Carbonation of Concrete.

Carbonation phenomenon in concrete occurs when calcium hydroxides (lime) of the hydrated Portland cement react with carbon dioxide from atmospheres in the presence of moisture and form calcium carbonate. To a small extent, calcium carbonate is also formed when calcium silicate and aluminates of the hydrated Portland cement react with carbon dioxide from atmosphere. Carbonation process in concrete results in two deleterious effects.

1. Shrinkage may occur

2. Concrete immediately adjacent to steel reinforcement may reduce its resistance to corrosion.

The rate of carbonation depends on permeability of concrete, quantity of surplus lime and environmental conditions such as moisture and temperature.

When fly ash is available in concrete; it reduces availability of surplus lime by way of pozzolanic reaction, reduces permeability and as a result improves resistance of concrete against carbonation phenomenon.

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1.2.4Sulphate Attack

Sulphate attacks in concrete occur due to reaction between sulphate from external origins or from atmosphere with surplus lime leads to formation of ettringite, which causes expansion and results in volume destabilization of the concrete.

Increase in sulphate resistance of fly ash concrete is due to continuous reaction between fly ash and leached out lime, which continue to form additional C-S-H gel. This C-S-H gel fills in capillary pores in the cement paste, reducing permeability and ingress of sulphate ions

1.3 SELF-COMPACTING CONCRETE

SCC concept can be stated as the concrete that meets special performance and uniformity requirements that cannot always be obtained by using conventional ingredients, normal mixing procedure and curing practices. The SCC is an engineered material consisting of cement, aggregate, water and mineral admixtures like fly ash, pond ash etc. and chemical admixtures to take care of specific requirements, such as, high-flow ability, high workability, compressive strength, enhanced resistances to chemical or mechanical stresses, lower permeability, durability, resistance against segregation, and possibility under dense reinforcement conditions. The main characteristic of SCC is the higher cement matrix aggregate ratio with respect to an ordinary concrete. In other words, the volume of cement matrix responsible for the mobility of the concrete mixture must be increased in order to push the aggregate under the gravity action or under the pressure of a pumping system. On the other hand, the volume of the aggregate in particular the coarse aggregate must be reduced in terms of both volume and maximum size, to improve the mobility and the segregation-resistance of the fresh mixture.

2.1 METHODOLOGY

a. Testing of material properties on cement, coarse aggregate, and fine aggregate.
b. Investigation on fly ash and pond ash
c. Preparation of mix design for self-compacting concrete
d. Evaluation of compressive strength of self-compacting concrete with fly ash and pond ash
e. Evaluation of flexural strength of self-compacting concrete with fly ash and pond ash
f. Casting of self-compacting concrete beams with and without fly ash and pond ash
g. Testing of self-compacting concrete beams with and without fly ash and pond ash
h. Compilation of extensive data on the strength, deformation and failure characteristics as well as ductility of the self-compacting concrete beams with fly ash and pond ash
i. Analysis of test data of self-compacting concrete beams with and without fly ash and pond ash
j. Presentation of detailed summary of recommendations and guidelines for effective utilization of fly ash and pond ash in self-compacting concrete beams in construction industry.

The following materials which can be used in the present experimental work.

- Ordinary Portland cement
- Aggregate
- Glenium (Super Plasticiser)
- Water
- Fly ash
- Pond ash

3.1 Test Setup and Methods

Slump Flow Test and T50 Slump Flow Test

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This test is used to measure the free horizontal flow of SCC on a plain surface without any obstruction. Concrete poured in slump cone without external compaction is made to flow on flow table. Time required for the concrete to cover 50 cm diameter spread circle (T50 cm time) from the time the slump cone is lifted is noted. Average flow of concrete after concrete stops flowing is measured to ascertain the slump flow value. It is most commonly used test and gives a good assessment of filling ability and indications on stability of the mix. In case of unstable mix, most of the coarse aggregate particles remain in the center of the flow table and only cement mortar flows. Absences of uniform distribution of larger particles across the spread indicate the poor viscosity of the mix. Intentional depressions created by finger, if not melded after removal of finger, indicate that the mix is segregated.

Fig 3.1 slump flow test.

V-Funnel Test

This test is conducted to assess the fluidity and segregation resistance of SCC. Inverted cone shaped equipment with 75 mm square opening at the bottom is used to assess the properties of mix such as unacceptable viscosity, undesirable volume of coarse aggregate, stability etc. V-funnel test is an important tool to assess the consistency of the mix. Uniformity in flow properties of fresh concrete during the production and before placement of concrete into the form can well be measured using V funnel test. To assess the consistency/fluidity of the mix, measurement of T 0 i.e., the time required for emptying the concrete filled V-funnel completely in seconds is measured by filling the funnel up to top with concrete without any external efforts and emptying immediately thereafter.

A stable mix having T 0 in between 6 to12 seconds is considered to be satisfactory. Stability of the mix is ascertained by measuring the time (in seconds) required to empty the V-funnel completely 5 minutes after filling the funnel completely.

This time is referred to as T 5. If the mix is segregated, T 5 time will be abnormally high as T 0 time. Interrupted flow is also observed in such cases. Fig.1 shows the flow of concrete with uniform distribution of coarse aggregates across the spread.

Fig 3.2 V Funnel test.

L-Box Test Method

This test is conducted to assess the filling and passing ability of SCC. Uniformity of the mix is also examined by inspecting sections of the concrete in the horizontal section of „L‟ box. Apparatus as shown in Fig. 3.2 consist of rectangular box section in the shape of „L‟.

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Concrete is made to pass through the obstructions of known clearances. The vertical section is filled with concrete, and then the gate lifted to let the concrete flow into the horizontal section through vertically placed reinforcements. When the flow is stabilized, the height of concrete h1 (at obstructions) and h2 (at the end of horizontal section of „L") with respect to base are measured.

The ratio of h2 and h1 referred to as blocking value, a measure of passing ability of SCC, is calculated. Blocking value of a stable concrete between0.8 to 1.0 indicates better passing ability.

Fig 3.3 L- Box Apparatus

Fill Box Test

This device is used to measure the filling ability of SCC. It consists of a transparent rectangular box as shown in Fig. 3.4, with number of obstacles through which the concrete is let to flow. The apparatus is placed on a firm level support having a height of 1 meter approximately. Concrete is filled in the box through the funnel provided at the topside of the box till it covers the top-most obstacles at the rear end of the box. The height of the concrete at both the ends is measured to calculate volume of concrete filled.

Compare the net volume of concrete filled with respect to the contained volume of the box up to the top of the top most obstacles, which gives the filling capacity of SCC.

Fig 3.4 fill box apparatus.

EXPERIMENTAL PROGRAMME

4.1DETAILS OF TEST SPECIMEN

Cubes of 150 mm * 150 mm are used for determining the compressive strength of concrete. Cylinders of 150mm * 300mm are used for determining the splitting tensile strength concrete. 100 mm * 100 mm * 500 mm prisms are used for determining the modulus of rupture. The specimens shall be cast with and without pond ash. Three specimens in each category shall be tested.

The test programme shall be intended to study the flexural behaviour of concrete beam made with and without pond ash. A total of 9 beam specimens with two different volume fractions shall be cast and tested in this study. The pond ash is added in concrete at two different volume fractions of 25 %, and 50% respectively. Three beam specimens shall be cast for each category. The details of beam specimens are shown in Table 4.1

Table 4.1 details of beam specimen.

Category	Types of beam	Volume fraction of fibers	Description of specimen	No of specimen
1	Without	-	Control	1

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	pond ash		Beam – reference beam	
2	With pond ash	25%	Concrete beams (25% partial replacement of fine aggregate in concrete mix)	3
3	With pond ash	50%	Concrete beams (50% partial replacement of fine aggregate in concrete mix)	3

RESULTS AND DISCUSSION

5.1Compressive strength test value

S. No	Types of specimen	7 Days	28 days
		Compressive strength N/mm²	
1	**Without pond ash**	4.72	6.29
2	**Without pond ash (25%)**	6.2	11.3
3	**Without pond ash (50%)**	5.8	10.81

5.2 Split tensile strength test value.

S. No	Types of specimen	Tensile strength N/mm²
1	**Without pond ash**	1.06
2	**Without pond ash (25%)**	1.75
3	**Without pond ash (50%)**	0.67

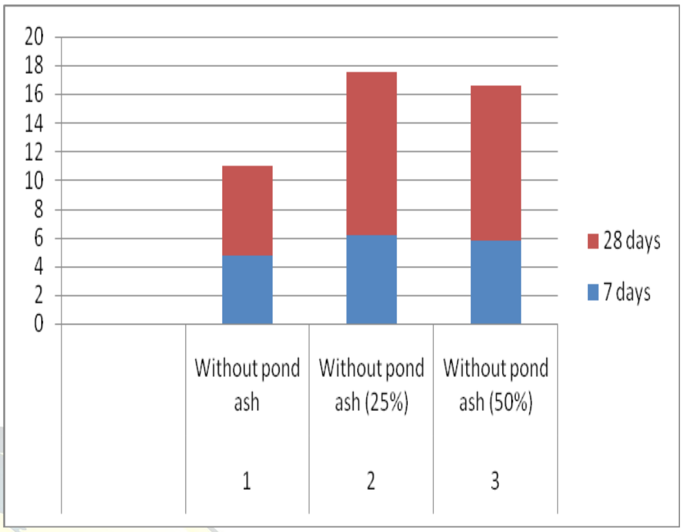

Fig 5.1 Compressive strength comparison chart.

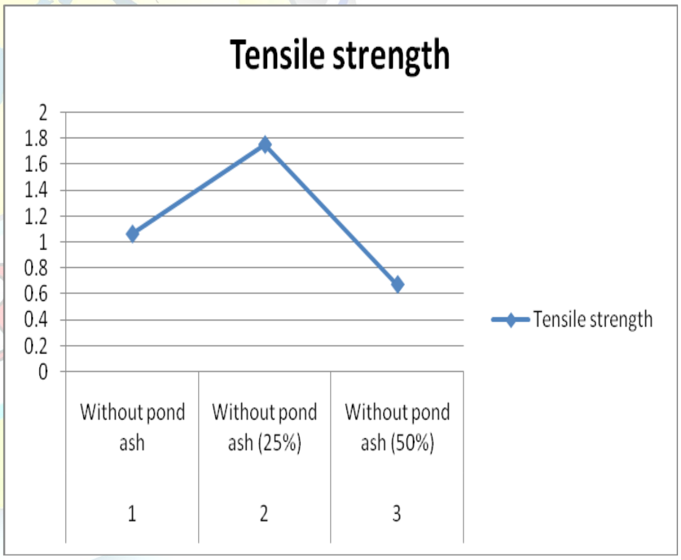

Fig 5.2 tensile strength comparison chart.

CONCLUSION

From this study, it was observed that, though self compacting concrete has comparatively high strength values, but it has desirable strength values to be used for both structural and non-structural purposes. Abolishment of cement by replacing fly ash content from normal concrete mixes lead to higher porosity and lowers cement requirement. Since it compacts well due to its self-weight, it needs no mechanical

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compaction. As it is a light weight concrete, the necessity for stronger shuttering requirement is not needed. Self compacting concrete can be used effectively for load bearing walls, as drainage medium in play areas & tennis courts and for pavements, temporary structures. Also, SCC concrete can be effectively used for 25% replacement of fly ash in self compacting concrete owing to only a marginal increase in compressive strength values. But for 50% replacement level, the decrease in strength values is 10% and more which is not desirable.

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