Flexural Behaviour of RC Beam with Pond Flyash and ESP FlyAsh

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Abstract: The use of Supplementary Cementitious Materials (SCM) such as Fly ash, Granulated Slag and Silica fume as a replacement for Portland cement in concrete presents one viable solution with multiple benefits for the sustainable development of the construction industry. Out of various supplementary materials, Fly ash is the most widely used material worldwide. Fly ash has excellent structural and durability characteristics. The pore filling effect and pozzolanic properties of Flyash improves the properties of fresh and hardened concrete. In addition to the cost saving bythe replacement amount of cement; it reduces co2emission during the manufacture of Portland cement. In the present investigation, a controlled beam and six number of ESP flyash and Pond flyash beams of size 200 x 100 x 1700 mm were cast. This paper deals with the investigation on the flexural behaviour of beam with pond flyash and ESP (Electro static precipitated) flyash at various cement replacement levels of 4%, 6%, and 8% and the results are compared with controlled beam. The flexural test was conducted to determine the ultimate load carrying capacity of the beams and their corresponding mid span deflection, load point deflection, crack pattern, Stress vs strain are measured. The flexural strength of ESP flyash is increased 24.76% for 8% replacement level and pond flyash is increased 10.97 % for 6% replacement level than controlled beam respectively. This study revealed that the replacement of cement by flyash concrete provides higher compressive strength & flexural strength compared with controlled concrete.

INTRODUCTION

We are constantly faced with ever-large economical problems associated with the emission of CO2in to the atmosphere. The increasing scarcity of raw materials and an urgent need to protect the environment against pollution has accentuated the significance of developing new building materials based on industrial waste generated from coal fired thermal power station and is creating unmanageable disposal problems due to its potential to pollute the environment. The utilization of by-products as the partial replacement of cement has important economical, environmental and technical benefits such as the reduced amount of waste materials, cleaner environment, reduced energy requirement, durable service performance during service life and cost-effective structures. It is well known that blending cement with fly-ash improves the rheological properties of hardened concrete. These improvements are generally attributed to both the physical and chemical effects. The physical process is due to the particle fineness of the supplementary cementing materials that are much smaller than that of the cement, thereby providing densely packed particles between fine aggregates and cement grains, and hence, the reduction in porosity. The chemical process is due to the activation of the non- crystalline silica, the major constituent of fly-ash, by the calcium hydroxide produced from the hydrating cement to form secondary calcium silicate hydrate that also fills the pore spaces and further reduces the porosity. This paper deals with the concrete containing supplementary cementing material: fly-ash. Because of the wide availability and low cost, coal fly-ashes are the most commonly used in the manufacture of cement-based materials to improve their microstructure. The compressive strength-developing behavior of concrete containing fly-ash widely differs from that of concrete without fly-ash depending on the method and the amount of fly-ash addition. The rate of strength increase of fly-ash concrete is slower but it is sustained for longer periods than the rate of strength increase of Portland cement concrete. Flyash is a by-product of Pulverized coal blown into fire furnace at a power generating plant. Coal, ground to the consistency of flour ignites when blown into the furnace and a certain amount of non- burnable material residue remains as slag or airborne particles known as flyash.

The airborne particles are removed by mechanical collectors called Electro Static Precipitators (ESP) or wet scrubbers. The flyash production amounts to approximately 60-100 million tons per year at present in the country and this is likely to exceed 175 million tons by the end of 2009 and therefore, will become a serious problem as far as availability of land and pollution hazards are concerned. In India only 2% of the produced flyash is currently being utilized and there is vast scope for its effective utilization. At present there are more than 72 thermal power stations in India. Safe environment-friendly disposal of these ashes is of major concern. Hence attempts should be made to utilize ash rather than dumping the same thereby losing thousands of hectares of land. Conventionally about 15-30% of cement is being replaced in the concrete with flyash. But investigations have tried even with higher percentages (up to 70%) and achieved good results particularly in pavement and marine structures and roller compacted concretes.

LITERATURE SURVEY

Kode Venkata Ramesh and D. Sree Ramachandra Murthy presented a paper on “Flexural response of RC beams of high volume flyash concrete”. In this paper, carried out an experimental study on flexural response of reinforced concrete beams that were cast replacing up to 50 percentage of cement by flyash. The flexural response of HVFA Concrete beams was compared with that of control concrete beam. He has concluded that there was no difference in strength, deformations and structural performance between the control and HVFA control beams.

N.Chitharanjan presented a paper on “Feasibility study of using flyash concrete for reinforced flexural member”. This article enumerates the outcome of detailed experimental investigations carried out to ascertain the feasibility of using Flyash concrete for reinforced flexural members. This study revealed that the bulk usage of Flyash for reinforced flexural members with a substantial saving in cost of feasible. M.A. Rashid and M.A. Mansur presented a paper on “Reinforced High-strength Concrete Beams in flexure”, described about the flexural test results generated on 16 reinforced concrete beams to evaluate the implications of using high-strength concrete(HSC). Test parameters considered include concrete compressive strength, ratio of tensile and compressive reinforcements and spacing of lateral tries. He concluded that at service load maximum crack width is not significantly affected by the tensile reinforcementration (p) for the range employed with the study, but it increases as concrete strength is increased.

Amit Mittal .M.B, Kaisare, Rajendrakumar sheti presented a paper “Experimental study on use of fly ash in concrete”. This paper carried out an experimental study on concrete that were cast, with replacement levels of 20%, 30%, 40% and 50%, it described the effect of flyash on workability, setting time, density, compressive strength, shrinkage and permeability.

Saricimen studied the effect of curing method on permeability characteristics of plain and Flyash blended cement concrete. Both water and air curing method were used. It was observed that in both the methods, flyash blended concrete showed less permeability than plain cement concrete at 7 days curing. Pore refinement of blended cement concrete was identified that Fly ash concrete is more sensitive.

OBJECTIVE OF INVESTIGATION

The objectives of the present investigation are

- To study the physical properties of pond fly ash, ESP fly ash and cement.
- To study the mechanical properties of pond fly ash and ESP fly ash under various percentage of replacement levels
- To study the behaviour of fly ash reinforced concrete beam in flexure for load–deflection behaviour, patterns of cracks, moment of resistance and load at first crack.
- To determine the flexural behaviour of RC beam with pond fly ash and ESP fly ash as cement replacement

EXPERIMENTAL INVESTIGATION TEST METHODS

- Physical properties
- Strength properties
- Flexural Strength

Physical properties of cement and flyash are studied by the following tests

- Specific gravity
- Specific surface

Strength properties of the ESP flyash and pond fly ash concrete are studied by conducting the following test

- Load–deflection behaviour
- Stress vs strain
- Pattern of crack
- Load at first crack
- Moment of resistance

SIZE OF SPECIMEN

Cube specimen: 150mmx150mmx150mm
Beam specimen: 200mmx100mmx1700mm
The following table represents the number of specimen cast in detail

Table4.1 casting of specimen

S.No	Replacement level	Size of specimen in mm	No of specimen
1	0%	150mmx150mmx150mm	3
	4%	150mmx150mmx150mm	3
	6%	150mmx150mmx150mm	3
	8%	150mmx150mmx150mm	3

2	0%	200mmx100mmx1700mm	1
	4%	200mmx100mmx1700mm	2
	6%	200mmx100mmx1700mm	2
	8%	200mmx100mmx1700mm	2

PHYSICAL PROPERTIES OF CEMENT, ESP FLYASH AND POND FLY ASH

Specific gravity and specific surface were found and their results are tabulated in Table 5.1 and 5.2

STRENGTH TESTS

Following tests are conducted for evaluating strength properties of ESP fly ash and pond fly ash

Compressive Strength Test

150mm X 150mm X 150mm concrete cubes were casting using M20 grade concrete with w/cratio 0.50.Specimens with ordinary Portland cement (OPC) and OPC replaced with pond flyash and esp flyash at 4%, 6% and 8% levels were cast. During casting the cubes were mechanically vibrated by using a table vibrator. After 24 hours, the specimens were removed from the mould and subjected to water curing for 28 days. After curing, the specimens were tested for compressive strength using a calibrated compression testing machine of 140 KN/min capacity.

The cube Compressive strength (F_{ck}) was computed, from the fundamental principle as

F_{ck} = Ultimate load (KN) / cross sectional area

Fig 4.1 Compression Testing Machine

FLEXURAL STRENGTH TEST

Flexural strength of concrete is found by testing plain concrete beams. Beams of size 200mmX100mm X 1700mm were cast using M20 grade concrete with w/c ratio of 0.5. Specimen with OPC and OPC replaced with pond flyash and ESP flyash at 4%, 6% and 8% levels were cast. After 24 hours, the specimens were removed from the mould and subjected to water curing for 28 days. After the curing, the beams were subjected to flexure test by two point loading using flexural testing machine of 500kN capacities. All the specimens were tested under two point loading system. The beams (control, 4%, 6%, 8% replacement levels of pond fly ash and ESP fly ash) were white washed before testing. Two concentrated loads at one third spans were applied on the beam by means of 50 tonnes capacity. Two dial gauges having a least count of0.01mmwereplacedunderthebeam.Onedialgauge was placed at the centre of the beam while the other dial gauge placed under the concentrated loads to record the deflections at these two positions. During the testing of beams, load at first crack, ultimate load and deflections were observed.

DETAILS OF TEST SPECIMEN

Number of Beams

Totally 7 beams of size 1700mmx100mmx200mmwerecast and they were tested, after 28 days fully immersed curing in water.

Reinforcement Details

Top reinforcement: 2 Nos. of 8mm Dia. Bar Bottom reinforcement: 2 Nos. of10mm Dia.bar Stirrups: 6mm dia # 150mm c/c

Specimen details:

Beam size: 200x100x1700mm
Total number of specimens = 7 numbers
Controlled specimen =1number
Beam with pond fly ash replacement

(4%, 6%, 8%) =3numbers Beam with ESP fly ash replacement
(4%,6%,8%) =3numbers
Total =7numbers

Fig 4.2 Experimental Setup

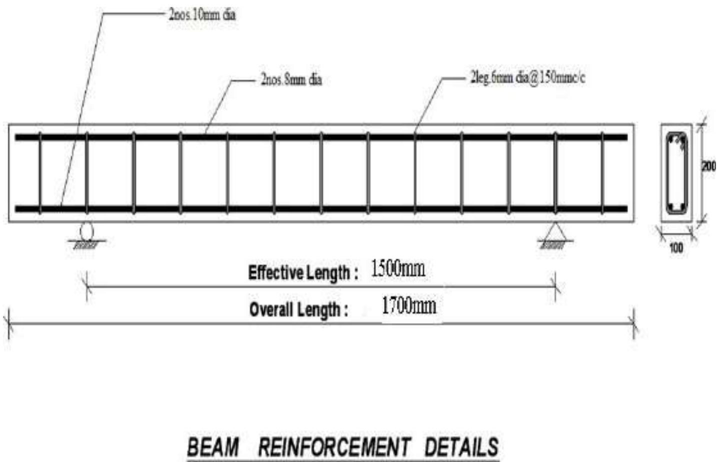

Fig 4.3 Reinforcement Detail

Test procedure

The beams were simply supported over an effective span of 1700mm and the loads were applied vertically and monolithically as two point static loading, at the middle third position of the beam, vertical displacements and strains were monitored throughout the test. Displacements were measured at mid-span and at location of the applied loads. The strain was measured by a DEMEC (detachable mechanical gauge) with gauge points.

The beams were loaded using hydraulic jack. The load was measured by means of load cell. The load was applied at an increment of 3.3 KN, deflections were measured. The50tonecapacitytestingframe was used for testing of beams.

CASTING OF REINFORCED CONCRETE SPECIMENS

In this casting process, all the ingredients were mixes in dry condition. To the dry mix, calculated quantity of water was added and thoroughly mixed to get a uniform mix. Machine oil was smeared on the steel mould and the Reinforcementc age was placed in position. Concrete was poured in the three layers and each layer was compacted.

CURING OF SPECIMENS

Specimens under normal conditions were cured using normal water for curing purpose.

EXPERIMENTAL TEST SET UP

All the specimens were tested under two point loading system. Figure gives the details of specimen and test set up. The beams were subjected to flexure test by two point loading using flexural testing machine of 500kN capacities. All the specimens were tested under two point loading system. The beams (control, 4%, 6%, 8% replacement levels of pond fly ash and ESP flyash) were white washed before testing. Two concentrated loads at one third spans were applied on the beam by means of 50 tonnes capacity. Two dial gauges having a least count of 0.01mm were placed under the beam.

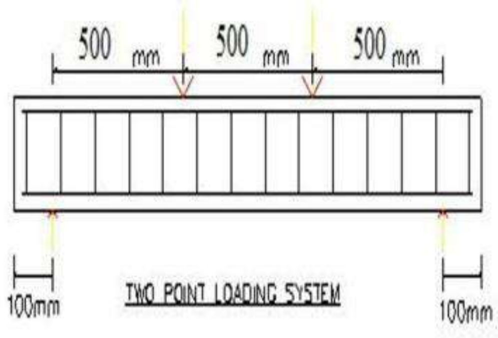

Fig 4.4 Test Setup for Beam

One dial gauge was placed at the centre of the beam while the other dial gauge placed under the concentrated loads to record the deflections at these two positions. The deflection at a load increment of every 5 KN was recorded till the failure. During the testing of beams, load at first crack, ultimate load and deflections were observed and the results are reported in the tables. The beams were tested at least 3 days after curing.

PROPERTIES OF MATERIALS

CEMENT ESP FLYASH AND POND FLYASH

Dalmia43 grade cement and ESP flyash and Pond flyash from Neyveli Thermal power station is used throughout this investigation**.** The tests conducted on cement and ESP flyash and pond flyash were specific gravity, surface area and their values are given in the following tables.

Table 5.1 Specific gravity of cement ESP flyash and pond flyash

S.No	Material	Specific Gravity
1	Cement	3.13
2	ESP flyash	2.27
3	Pond flyash	2.15

Specific gravity of 43 grade ordinary Portland cement was obtained as3.13, Specific gravity of ESP flyash was obtained as 2.27andpond flyash was obtained as 2.15.

Table 5.2: Physical Properties of Cement and ESPFly Ash and Pond Fly ash

S.No.	Material	Specific Surface in cm^2/gm
1.	Ordinary Portland Cement	3976
2.	ES Pflyash	4015
3	Pond fly ash	5688

The Specific Surface of the Fly ash is higher than the Ordinary Portland cement, which indicates the fineness of Fly ash is more than the OPC. From the above table (5.2) the specific surface area of ESP flyash and pond flyash is more as compared with opc. The development of earlier strength is mainly due to this specific surface area. So we can get the maximum earlier strength by using ESP flyash and pond flyash with cement

5.3 CHEMICAL PROPERTIES OF ESP FLYASH

Table 5.5 shows the chemical properties of flyash, in which the silica content is more where as the other constituent Iron, Alumina, Cao, Mgo, sodium, Potassium and sulphate found comparatively low. The presence of silica content reacts with the calciumhydroxide results from hydration process of Portland cements and form gel. These gel formations increase the strength of matrix.

FINE AGGREGATE

The fine aggregate used in this investigation was clean river sand passing through 4.75mm sieve fine fineness modulus of 2.25 and specific gravity of 2.67. the particle size distribution is given in the table

Table 5.4 Properties of Fine Aggregate

Test particulars	Result obtained
Specific gravity	2.67
Fineness modulus	2.25
Size	Passing through 4.75mm sieve

Coarse Aggregate

For the high strength concrete, the maximum size aggregate should be less. So size of crushed angular aggregate used in this experiment was between 12.5mm and 4.75mm with the specific gravity of 2.6 and fineness modulus of 5.96.
The particle size distribution of coarse Aggregate was given in the table

Table 5.4 Properties of Coarse Aggregate

Test particulars	Result obtained
Specific gravity	2.6
Fineness modulus	5.96
Size	Passing through 20mm sieve and retained in 10mm sieve

WATER

portable water generally considered satisfactory for concreting purpose. Since the present investigation involves comparison of performance of concrete in normal environments. Locally available potable water obtained from source of college pore well was used for mixing and curing for normal concrete.

CONCLUSIONS

From the specific surface area results the ashes (ESP flyash and pond flyash) having more specific area than the cement this will leads to form strong gel while adding water. The formation of this gel leads to reduce the segregation of aggregate. The cube compressive strength of ESP flyash replaced concrete is higher than the controlled concrete and pond flyash replaced concrete is higher than the control concrete up to 6% replacement. The water demand of concrete containing fly-ash increases with increasing amount offly ash. The increase is primarily due to the high surface area of the fly ash. The ultimate load resisting capacity of Pond fly ash replaced R.C beams are higher than the controlled R.C beams up to 6% replacement is 10.97% and ESP flyash replaced R.C beams are higher than the controlled R.C beam is 24.76%. Hence from this study it can be recommended the cement may be replacement by pond flyash is increasing 7.21% and 10.97 % for 4%, 6%replacement level respectively and ESP flyash increasing 8.93%, 15.98%, 24.76 for 4%, 6%, 8% ESP fly-ash replacement. From the results obtained it maybe concluded that theESP fly-ash Pond flyash replacement of cement shows a higher value in all appreciable characteristics than the controlled specimens.

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