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SOME STUDIES ON POND ASH CONCRETE STRUCTURAL ELEMANT

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Abstract — *Energy consumption and generation is increasing day by day thanks to speedy industrial enterprise & urbanization. A larger portion of the energy is generated by Thermal Power Plants. Pond ash (PA) and different by-products from these plants square measure disposed in giant quantities. Pond ash utilization helps to scale back the consumption of natural resources. Hence there's scope for victimization pond ash as Fine aggregate (FA). Use of different material in concrete like industrial by-products like Coal Ash (Fly Ash and Lake Ash) is eco-friendly.*

During the combustion of powdery pulverized coal at the thermal powerhouse the merchandise fashioned square measure bottom ash, ash and vapors. This bottom ash is that a part of residue that is amalgamated into particles and is collected at the bottom of the furnace chamber. In India most of the thermal power plants adopt wet methodology of ash disposal. The ash collected from Electrostatic precipitator device and therefore the bottom ashes square measure mixed with water and disposed in a very suspension type in bigger sized ponds and dykes. Fly ash acts each as a fine aggregate and as cement. Pond ash differs from fly ash collected from Electrostatic precipitators in a very dry type in this it contains important quantity of comparatively coarser particles (greater than 50 µm and up to 150 to 160 µm). Use of this matter can have large scale impact on green House effect.

This experimental study is to research the behavior of traditional concrete beam with concrete containing Pond ash as fine aggregate (partial replacement).The present study indicate the flexural behavior of traditional Concrete and concrete with 20% replacement of fine aggregate with pond ash. The results will conclude comparable behavior of pond ash with traditional concrete.

***Keywords**- urbanization, victimization, merchandise, dykes, flexural*

I. INTRODUCTION

Industrialization and urbanization are the two processes that are going on unabated all over the world. Apart from the advantages realized due to these processes, one has to look in to their adverse impact on the global environment and on social life. Most important ill effects due to these global processes are

- Production of huge quantum of industrial waste by-products due to the vast demand for power and the problems related with their safe storage and disposal.
- Scarcity of good materials for constructional activities, which include infrastructure development.

Coal produced electricity takes about 80 % of the total power generated in India. The Indian power plant uses coal like Gondwana coal; it has low calorific value and high ash content which requires 0.7 kg of coal to generate a 1 kwh of electricity. Statement of the Problem

The coal primarily based station generates an enormous quantity of ash. In India, it's concerning a hundred and seventy MT for the year 2011-12 and is anticipated to be on top of 600MT for the year 2031-32. The generated ash contains concerning 20% pond ash and 80% fly ash of the overall ash generated. Fly ash is been recycled as another alternative to cement whereas pond ash is being disposed off. The disposal of huge amount of pond ash needs huge space of land, water and energy. If not managed well becomes a risk and damages the atmosphere. With enlarged power consumption the generation of coal ash has been growing annually and wish for extra disposal sites has become imperative. Thus recycled pond ash may be able to mapped out the on top of mentioned problems.

During the combustion of pulverized coal at the thermal power station the product formed are Bottom Ash, Fly Ash and Vapours. There bottom ash is the coarser material which falls into furnace bottom in modern large thermal power plants and constitute about 20% of total ash content of the coal fed in the boilers. In India most of the thermal power plants adopt wet method of bottom ash disposal. The fly ash collected from electro static precipitator and the bottom ash are with water and disposed in a slurry form in large ponds and dykes. Fly Ash can be used both as cement and fine aggregates. Pond ash differs from fly ash and it contains significant amount of relatively coarser particles (greater than 45µm and up to 150µm). The definitions of Bottom Ash, Fly ash, Pond ash and Pulverized Fuel Ash as per the code are as follows.

Bottom Ash — Pulverized fuel ash which is collected from the bottom of the boilers by wet or dry method process (Cl. 3.1:IS3812, Part I, 2003)

Fly Ash — Pulverized fuel ash separated from flue gases by any suitable method like cyclone separator or electro-static precipitator (Cl. 3.3:IS3812, Part I, 2003).

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Pond Ash — Pond ash is combination of fly ash and pond ash in any proportion and conveyed in the form of water slurry and collected in pond or lagoon (Cl. 3.5:IS3812, Part I, 2003).

Pulverized Fuel Ash — Ash generated by burning of powdered, pulverized or crushed coal or lignite fired boilers. It can be fly ash, bottom ash, pond ash or mound ash (Cl. 3.6:IS3812, Part I, 2003).

II. PRESENT STUDY

It is to study the behavior of Pond Ash Concrete Structural Elements with concrete containing pond ash as fine aggregates. Flexural behavior is considered for the present investigation.
This study will help in understanding the flexural behavior of pond ash concrete structural elements (Beams) indeed paving the way for large scale usage of pond ash which is otherwise environmentally hazardous material in the construction industry.
The large area of land (nearly one sq m of land per person) is required for the disposal of pond ash. It pollutes the atmosphere and also top soil. The present study will provide a noble solution of addressing above two issues simultaneously. It reduces the burden of disposal to large extent and reduces the dependence on depleting Natural River Sand has fined aggregate in concrete. This provides an eco-friendly approach for sustainable construction practices. This study will help to understand the usage of waste from Thermal Power Plant as a replacement material to fine aggregates.

III. OBJECTIVES

- To determine the Flexural Strength of the Structural Element i.e Beam.
- To Study the behavior of Pond Ash as fine aggregate in the concrete.

IV. STUDY ON MATERIALS

4.1 Cement (IS 12269-1987):-

Cement is a well-known building material and has occupied an indispensible place in the construction works. Cement is a fine powder substance which by itself is not a binding material but develops binding properties due to result of hydration. Cement is called hydraulic when the hydraulic products are stable in aqueous environment (water resistance).
There is a variety of cement available in the market and each type is used under certain conditions due its special properties. In this study Ordinary Portland cement (53 grade) is used for the investigation and construction works. It confirms all the requirements of Indian standard Specification as per IS: 12269-1987. The tests on cement are carried out as per IS: 4031-1991.

4.2 Coarse Aggregate (IS 383-1970):-

The coarse aggregate is outlined as associate mixture most of that is maintained on 4.75mm IS sieve. The aggregates are shaped as a result of natural disintegration of rocks or by artificial crushing of the rock or gravels. These properties are chemical and mineral composition, relative density, hardness, strength, pore structure. Other properties of the aggregate, that isn't possessed by the parent rocks, are particle form and size, texture and absorption. of these properties could have a substantial result on the standard of concrete in recent and hardened state. The common coarse aggregates are crushed stone and gravel. The scale of the aggregates typically used was 16mm down at 100 percent and 12.5 mm down at 50%. Crushed granite jelly obtained from machine device is employed as coarse aggregates. the mixture is also classified as rounded, partially rounded, flaky, angular, elongated supported its form and surface texture. typically angular aggregates are used for construction work. The angular mixture affects the workability or stability of combine, that depends on the interlocking of the particles. The properties of the coarse mixture are tested as per IS 383-1970.

4.3 Fine Aggregate (IS 383-1970):-

These are the fine particles, which can pass through 4.75mm , IS sieve. It is generally called as sand. Generally natural river sand is used for any construction work. The sand is generally considered to have a lower size limit 0.07mm. The material of size between 0.06mm to 0.002mm is known as silt. Smaller from these size particles are termed as clay. The properties of fine aggregates are determined by conducting tests as per IS: 2386-Part I.

4.4 Pond Ash (IS 3812-2003):-

When pulverized powdered coal is burnt in the furnace of the power plant, around 80 per cent of the ash produced is very fine in nature (Lee Bong Chun et.al, 2008). This part is carried along with flue gases and is collected by using Electro-Static or Cyclone precipitator. This is called Fly Ash. The remaining ash cinters and falls down at the bottom of the furnace. This is known as Bottom Ash**.** Fly ash may be disposed in dry form in ash mounds or through water slurry in a pond. When fly ash and bottom ash are mixed and disposed in the form of slurry to ash ponds, it is called as Pond Ash. For the purpose of these guidelines, the term ‘fly ash’ denotes any type of coal ash unless specifically mentioned.

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Coal Ash is causing environmental pollution, creating health hazards and requires large area of precious land for disposal. Due to increasing concern for environmental protection and growing awareness of the ill effects of pollution, proper utilization of large quantity of waste generated at Thermal Power Plants has become an urgent need and challenging task. Fly ash can be utilized in many ways as shown through extensive R&D efforts as well as field demonstrations. Bulk utilization is possible in the field of Civil Engineering applications.

The huge demand due to fast development in infrastructure, scarcity of natural sand in river bed and also due to government restriction on quarrying of sand, have has led to the increase in the cost of natural sand. This not only has increased the cost of the construction but also delays the construction in few places due to the non-availability of natural sand. This motivates researches for alternative material to replace the natural sand. Substitution of raw materials/constituents with alternatives is an important eco efficiency drive and is need of the hour. Hence an effort is made to use Pond ash in concrete as a partial replacement to sand to study its Compressive strength and the durability aspects of concrete with Pond ash as a constituent. Pond ash from Raichur Thermal Power Station (RTPS), Raichur, Karnataka was selected for the study.

4.5 Water (IS 10262-2009):-

It plays very important part in the concrete mass, as it actively contributes in a chemical reaction with cement. It is been estimated that on an average of water by weight cement is required for chemical reaction in cement compounds. Portable water should be free from any kind of injurious salts while mixing and curing process.

4.6 Chemical Admixture (IS 9103-1999):-

Chemical admixtures are the key ingredients added to the concrete which alters the fresh properties of the concrete. They alter the properties like workability, flow ability, viscosity and water reduction. Based on their purpose of usage they are classified accelerators, retarders, water reducing agents and super plasticizers or viscosity modifying agents. The admixture used in this project is the ECMAS HP 890 from ECMAS Construction Chemicals Pvt .Ltd. Bangalore which is one of the water reducing agents. This admixture is added to increase the workability and flow of the concrete.

V. EXPERIMENTAL STUDY

5.1 Cement:-

Ordinary Portland cement of 53 Grade confirming to IS 12269-1987 is used in this study. The physical properties of Cement are shown in the table below

Table-5.1 Physical test result of cement

SL No.	Test Name	Result Obtained	Result required as 12269-1987
1.	Consistency test(%)	33	26-33
2.	Specific Gravity	3.1	2.99-3.15
3.	Fineness modulus	4%	<10% of weight
4.	Initial setting time(min)	35	>30min

5.2 Fine Aggregate:-

Locally available good quality manufactured sand is used in this investigation. The tests conducted on fine aggregates and the results obtained are presented in below Table.

Table-5.2 Physical test result of Fine Aggregate

SL No.	Test Name	Result Obtained
1.	Fineness modulus	2.758
2.	Bulking	5 %
3.	Bulk density (kg/m^3) Loose density Compacted density	 1745.2 1955.71
4.	Silt Content	3.07 %
5.	Specific gravity	2.61
6.	Water Absorption test	9.1 %

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5.3 Coarse Aggregate:-

Locally available good quality of crushed Coarse aggregate were used in this investigation. The tests conducted on coarse aggregate and the results obtained are tabulated below.

Table-5.3 Physical test result of coarse aggregate

SL No.	Test Name	Result Obtained
1.	Fineness modulus	7.95
2.	Specific gravity	2.65
3.	Elongation %	26.85
4.	Flakiness %	
5.	Water Absorption test	3.1 %

5.4 Pond Ash:-

The Pond Ash which were used in this experimental work is taken from Raichur Thermal Power Plant Karnataka India. The tests conducted on pond ash and the obtained results are tabulated below.

Table-5.4 Physical test result of pond ash

SL No.	Test Name	Result Obtained
1.	Fineness modulus	3.62
2.	Bulking	3 %
3.	Bulk density (kg/m^3) Loose density Compacted density	 715.88 876.57
4.	Silt Content	0 %
5.	Specific gravity	1.95
6.	Water Absorption test	16.42 %

VI. ANALYSIS OF DATA

6.1 Compressive Strength

It is the strength of concrete defined as the load which may causes the failure of specimen, per unit area of c/s in uniaxial compression under a constant rate of loading. The specimens of size 150 x 150 x 150 mm for the various mix proportion for 0%, 20% replacement of fine aggregate with pond Ash were casted The compressive strength tests were conducted for the cubes after 7, 14 and 28 days of curing and the average compressive strength results are tabulated in the Table.

Table-6.1 Compressive strength value of concrete cube

Results of M_{25} Grade Concrete Compressive Strength			
% replacement of fine aggregate	**Compressive Strength (N/mm2)**		
	7 Days	**14 Days**	**28 Days**
0 %	29.49	38.89	43.21
20 %	24.47	31.01	35.00

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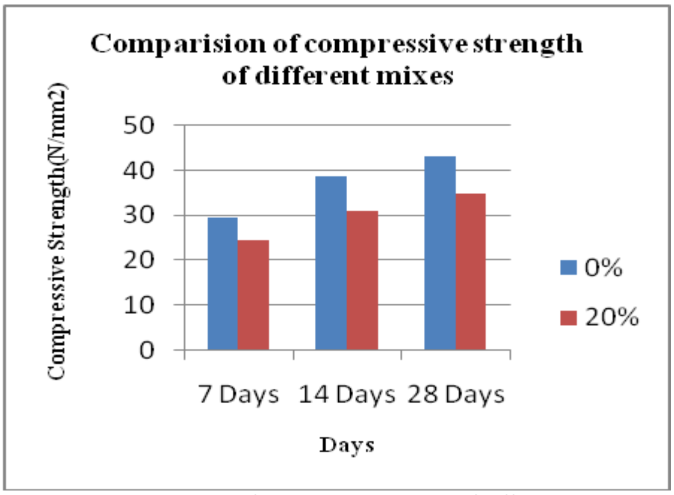

Fig-6.1 Comparison of compressive strength of different mixes

From the above result it is observed that both the mixes with 0% and 20% replacement of fine aggregate with pond ash were cured for a duration of 7,14, & 28 days. From chart it is seen that concrete with 20 % replacement of fine aggregate is getting some lesser strength as compare to concrete with 0% replacement of fine aggregate. The difference in strength is marginal but still getting the strength more than requirement that is 65%, 90% & 99% of target strength. The above chart gives an idea that initial gain of strength for the concrete with pond ash is less as compare to normal concrete. The difference in strength after 7 days of curing is around 5.02 N/mm^2, after 14 days is around 7.88 N/mm^2 and after 28 days is around 8.21 N/mm^2 From obtained data it is observed that pond ash can be a replacement of fine aggregate.

6.2 Flexural Strength

Flexural strength is the measure of the tensile strength of concrete. It is the measure of the resistance of the beam for failure in bending. Flexural strength can be determined by Dynamic & Static Flexural strength tests. Static flexural strength is adopted for the testing of the beam specimens. The RCC beam of size 2 x 0.25 x 0.3 m for the various mix proportion for 0%, 20% replacement of fine aggregate with pond Ash and with different amount of steel were casted. The casted beams were kept for curing for a period of 28 days. Then the beams are tested in flexural machine after a period of 28 days. The loading is recorded through the proving ring and the deflection was recorded from dial gauge. The maximum capacity of flexure testing machine is 50 tones.

6.2.1 Normal Concrete with 16 mm dia bars:-

Table-6.2 showing different variations

	A	B	C	D	E	F
1	Load	deflection @ mid section	Area	Stress	Depth	Strain @ mid
2	0	0	0.075	0	300	0
3	9	0	0.075	120	300	0
4	23	1	0.075	306.6666667	300	0.003333333
5	32	1	0.075	426.6666667	300	0.003333333
6	40	1	0.075	533.3333333	300	0.003333333
7	50	1	0.075	666.6666667	300	0.003333333
8	60	1	0.075	800	300	0.003333333
9	70	1	0.075	933.3333333	300	0.003333333
10	80	2	0.075	1066.666667	300	0.006666667
11	90	2	0.075	1200	300	0.006666667
12	111	2	0.075	1480	300	0.006666667
13	120	2	0.075	1600	300	0.006666667
14	130	3	0.075	1733.333333	300	0.01
15	140	3	0.075	1866.666667	300	0.01
16	151	3	0.075	2013.333333	300	0.01
17	160	3	0.075	2133.333333	300	0.01
18	170	4	0.075	2266.666667	300	0.013333333
19	180	4	0.075	2400	300	0.013333333
20	190	4	0.075	2533.333333	300	0.013333333
21	201	5	0.075	2680	300	0.016666667
22	211	5	0.075	2813.333333	300	0.016666667
23	221	5	0.075	2946.666667	300	0.016666667
24	230	6	0.075	3066.666667	300	0.02
25	241	7	0.075	3213.333333	300	0.023333333

normal concrete 16mm dia

Ready

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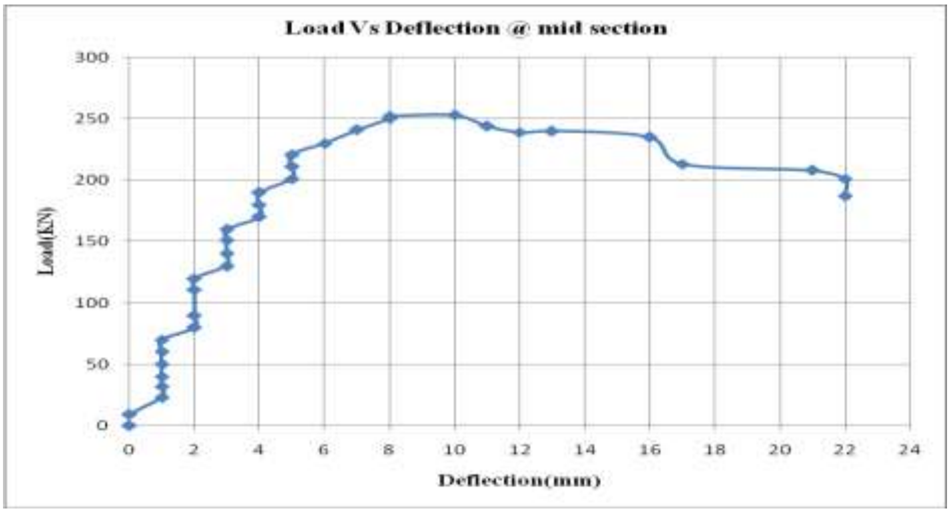

Fig-6.2 Load Vs Deflection @ mid section of the span

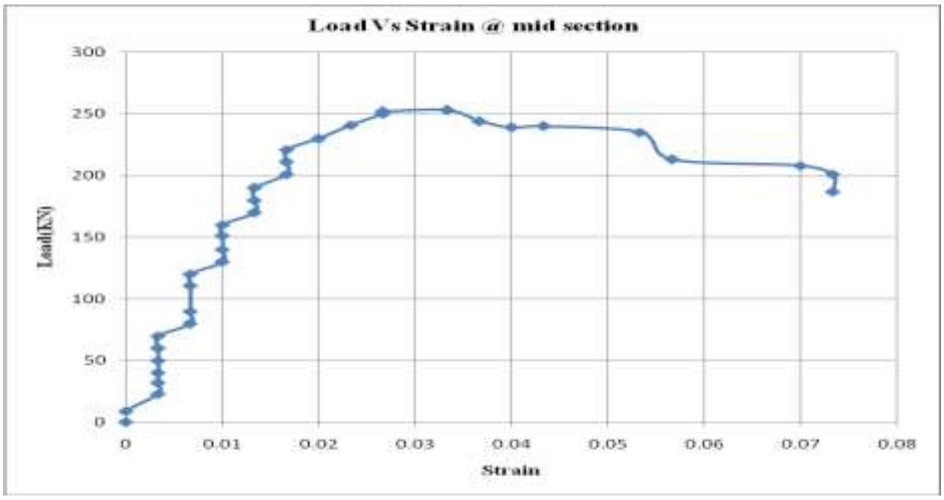

Fig-6.3 Load Vs Strain @ mid section of the span

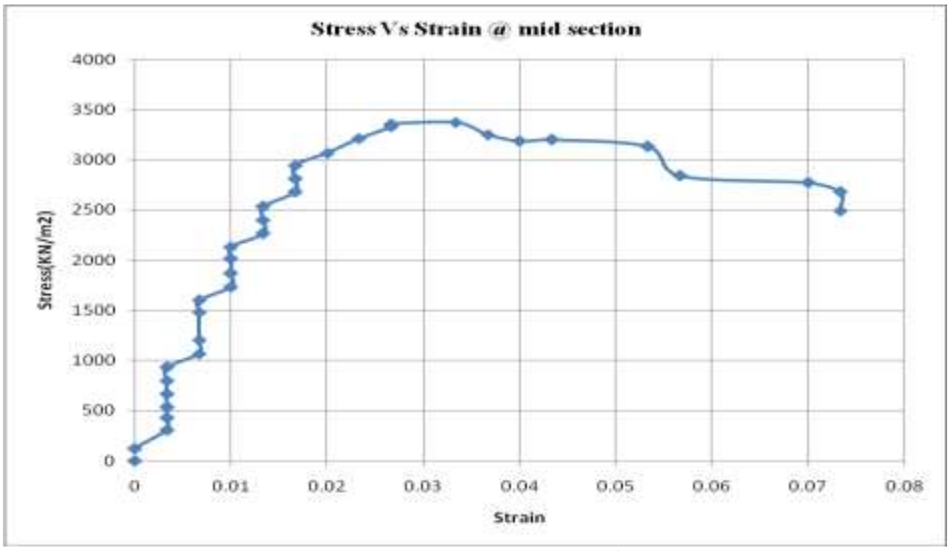

Fig-6.4 Stress Vs Strain @ mid section of the span

From the above figures and graphs it is seen that beam can have 253 KN of maximum load and it can have 22 mm of maximum deflection. It can have 3373.33 KN/mm^2 of maximum stress at maximum loading point.

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6.2.2 Concrete of 16 mm dia bars with 20 % replacement of fine aggregate with pond ash:-

Table-6.2 showing different variations

	B	C	D	E	F	G
1	Load 1(KN)	Deflection @mid	Area	Stress	Depth	Strain @mid
2	0	0	0.075	0	300	0
3	2	0	0.075	26.66667	300	0
4	18	1	0.075	240	300	0.003333333
5	30	3	0.075	400	300	0.01
6	40	3	0.075	533.3333	300	0.01
7	50	4	0.075	666.6667	300	0.013333333
8	60	4	0.075	800	300	0.013333333
9	70	6	0.075	933.3333	300	0.02
10	80	6	0.075	1066.667	300	0.02
11	90	7	0.075	1200	300	0.023333333
12	100	8	0.075	1333.333	300	0.026666667
13	110	9	0.075	1466.667	300	0.03
14	120	9	0.075	1600	300	0.03
15	130	11	0.075	1733.333	300	0.036666667
16	140	14	0.075	1866.667	300	0.046666667
17	151	14	0.075	2013.333	300	0.046666667
18	160	16	0.075	2133.333	300	0.053333333
19	170	17	0.075	2266.667	300	0.056666667
20	181	18	0.075	2413.333	300	0.06
21	190	19	0.075	2533.333	300	0.063333333
22	200	19	0.075	2666.667	300	0.063333333
23	211	20	0.075	2813.333	300	0.066666667
24	220	20	0.075	2933.333	300	0.066666667
25	230	21	0.075	3066.667	300	0.07

20%%16m

Ready

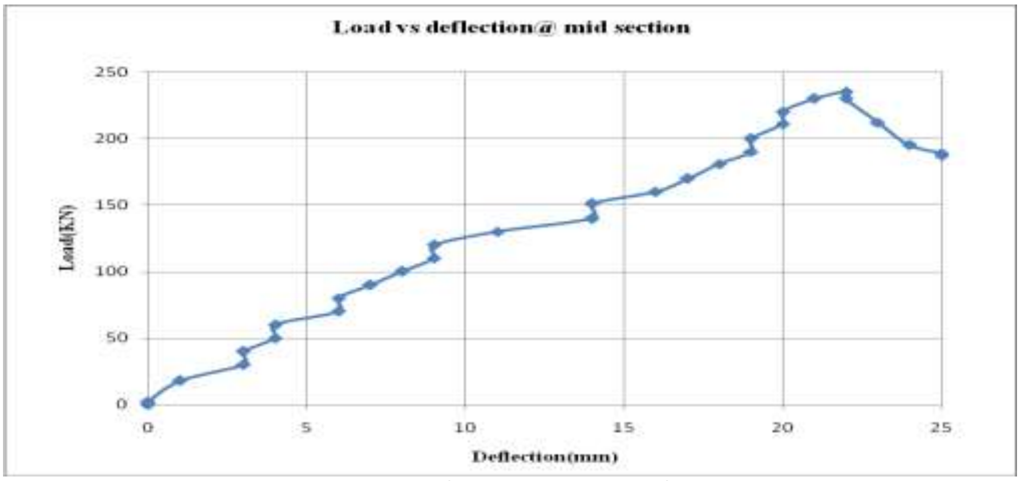

Fig-6.5 Load Vs Deflection @ mid section of the span

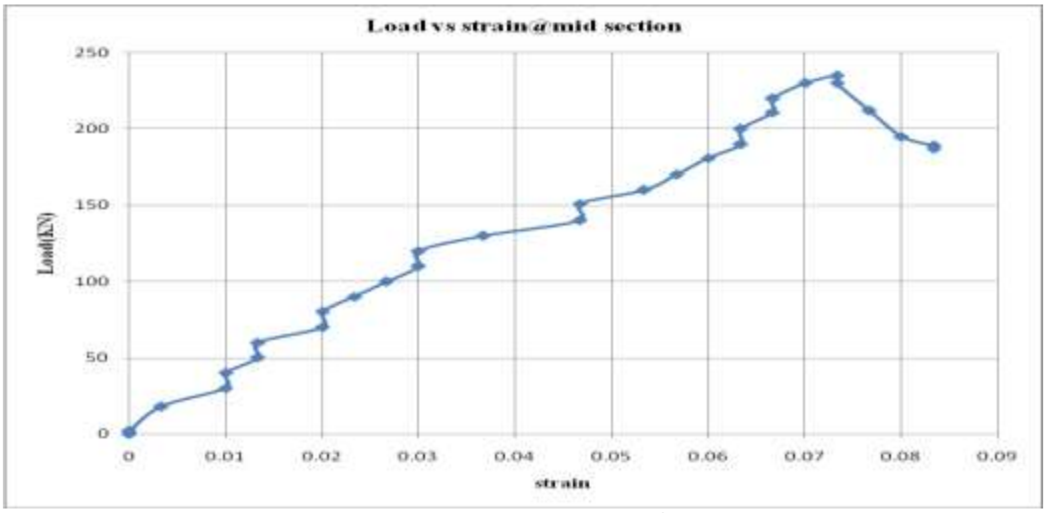

Fig-6.6 Load Vs Strain @ mid section of the span

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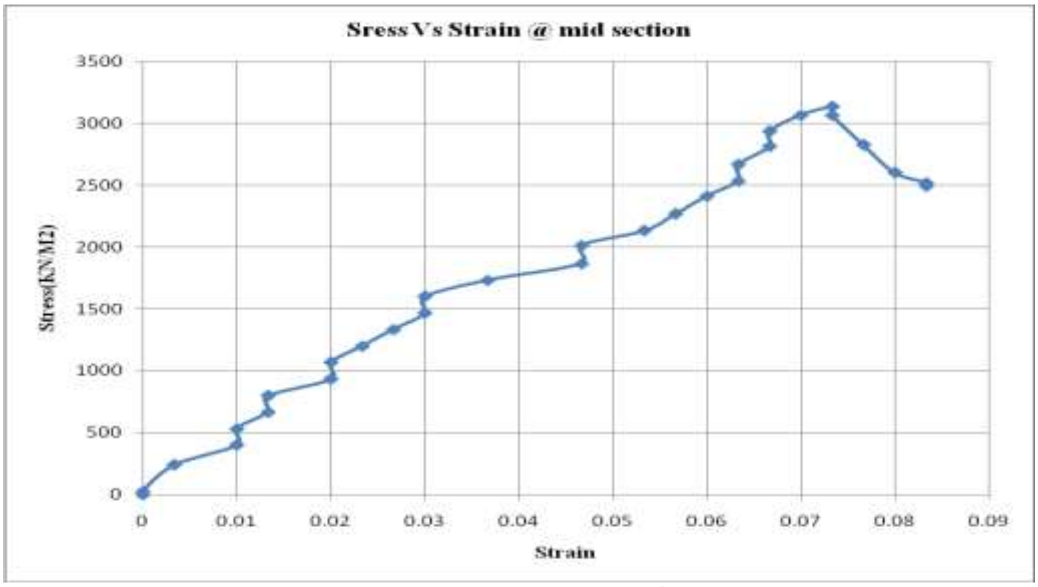

Fig-6.7 Stress Vs Strain @ mid section of the span

From the above figures and graphs it is seen that beam can have 235 KN of maximum load and it can have 25 mm of maximum deflection. It can have 3133.33 KN/mm^2 of maximum stress at maximum loading point.

6.2.3 Maximum Sustained load

Following results was obtained from the loading frame showing the maximum load sustained by the beam. Normal concrete mix and 20% mix replacement of fine aggregate with pond ash is showing relatively same strength having minor difference in maximum load.

Table-6.3 maximum load applied on different specimens

Normal Concrete with 0% replacement		
A_{st}(mm$^{2)}$	**Sample No.**	**Load (KN)**
339	1	136
	2	137
603	1	195
	2	253

Table-6.4 maximum load applied on different specimens

Concrete with 20% replacement with Pond Ash		
A_{st} (mm$^{2)}$	**Sample No.**	**Load (KN)**
339	1	136
	2	128
603	1	237
	2	235

Therefore from the above table it is observed that both the mixes with 0% and 20% replacement of fine aggregate with pond ash, with 28 days curing period the concrete with 20 % replacement of fine aggregate has gained more strength compare to concrete with 0% replacement of fine aggregate. The difference in strength is marginal but the strength is more than the target strength. From this the pond ash can be a good replacement of fine aggregate (Natural sand and M Sand) also it can reduce many hazardous environmental impacts of Pond Ash on nature.

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VII. CONCLUSION

i. Compressive strength of concrete:
- The difference in strength of cubes of normal concrete and 20% replaced pond ash concrete after 7 days of curing is around 5.02 N/mm^2, after 14 days is around 7.88 N/mm^2 and after 28 days is around 8.21 N/mm^2.It can be observed that pond ash can be a replacement of fine aggregate.

ii. Flexural behavior of beam:
- Normal concrete beams with 12mm dia bar took 137 kN of maximum load and 19 mm of maximum deflection. It is also seen that the maximum stress is 1826.627 kN/mm^2
- Normal concrete beams with 16mm dia bar took 253 kN of maximum load and it can have 22 mm of maximum deflection. It is also seen that the maximum stress is 3373.33 kN/mm^2 .
- Concrete beams with 20% replacement having 12mm dia bars took 128 KN of maximum load and it can have 18 mm of maximum deflection. It is also seen that the maximum stress is 1706.67 KN/mm^2.
- Concrete beams with 20% replacement having 16mm dia bars took 235 KN of maximum load and it can have 25 mm of maximum deflection. It also seen that the maximum stress is 3133.33 KN/mm^2.

iii. The comparison of compressive strength between normal concrete and concrete with 20% replacement of pond ash has been considered and it is seen that by replacement of fine aggregate with pond ash, the good strength concrete was obtained with a comparatively low fine aggregate content.

iv. Further studies on pond ash can provide a large scale use of this matter which will have large effect on Green House Effect.

VIII. SCOPE OF FUTURE STUDY

- Replacement of pond ash with fine aggregate can be studied for different other percentages.
- Study of replacement of pond ash from other thermal plants.
- Study of shear behavior by replacement of pond ash with fine aggregate.

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