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Investigation on Strength and Durability Properties of Pond Ash Concrete

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Abstract: Concrete is a construction material composed of Cement, Fine Aggregate, Coarse Aggregate, Water and Admixtures. River sand is the common material used as fine aggregate in many parts of the world. 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. Under such circumstances, the possibility of utilization of thermal power plant byproduct Pond Ash as replacement of fine aggregate in concrete is taken into consideration. The pond ash can be used as an alternative to the natural sand. Replacement of natural sand with Pond Ash is economical and helps to reduce the consumption of natural resources. Also it helps to resolve the problems associated with of disposal of the waste material and other environmental issues. Hence, this experimental investigation has prompted an interest for partial replacement of natural fine aggregate with waste material Pond Ash. The object of this study is to determine mechanical and durability properties of concrete with partial replacement fine aggregate with pond ash. The Fine Aggregate of 0%, 15%, 20%, 25%, and 30% is replaced with pond ash. The standard cubes, cylinders and Prisms having considered in this investigation. For this experimental investigation, 260 specimens are cast by replacing natural sand of 0%, 15%, 20%, 25%, and 30% with pond ash. The test result shows that, the workability of concrete is considerably decreased when the percentage of pond ash was increased. The compressive strength of pond ash concrete of grade M40 and M50 increases up to 20% replacement and decreases thereafter. The target mean strength of pond ash concrete at 28days is 52.15MPa and 63.11MPa for M40 and M50 grades achieved at 20% replacement of sand with pond ash. It is observed that the compressive strength of M40 and M50 grade pond ash concrete is increased by 8.31% and 8.12% conventional concrete. It is observed that, for 11.26% and 10.24% increase in flexural strength and 9.31% and 9.04% in splitting tensile strength of M40 and M50 grade concretes. Also observed that, durability tests water absorption, Permeability, Sorptivity and Acid Attack of Pond ash concrete is higher than conventional concrete but those values are within the permissible limits. The test results of investigation concludes that the strength and durability of concrete is encouraging for production of M40 and M50 grade Pond Ash concrete by replacing natural sand 20% with pond ash.

Keywords: Pond ash, Fine aggregate, waste material, environmental issues, strength and durability properties.

I. INTRODUCTION

Concrete is a construction material composed mainly of Cement, Fine Aggregate (Sand), Coarse Aggregate, Water and Admixture. River sand is the most commonly used Fine aggregate in many parts of the world. The huge demand for concrete has made this natural resource to get impoverished. On one side extraction of river sand in excess has conspicuous environmental impacts, on the other side, large quantity of coal ash is being produced every day in Thermal Power Plants, leading to many environmental problems. Pond ash is the by-product of thermal power plants, which is considered as a waste material and its disposal is a major problem from an environmental point of view and also it requires a lot of disposal areas. Actually, there are three types of ash produced by thermal power plants, viz. (1) fly ash, (2) bottom ash, and (3) pond ash. Fly ash is collected by mechanical or electrostatic precipitators from the flue gases of power plant; whereas, bottom ash is collected from the bottom of the boilers. When these two types of ash, mixed together, are transported in the form of slurry and stored in the lagoons, the deposit is called pond ash. The disposal of fly ash will be a big challenge to environment, especially when the quantum increases from the present level. Hence worldwide research work was 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 byproduct pond ash as replacement to fine aggregate in concrete is taken into consideration. The volume of pond ash produced by thermal power plants is very large compared to that of the other two ashes, viz. fly ash and bottom ash .The task to utilize the pond ash to the maximum possible extent is still a major problem throughout the world. To solve the problem, pond ash has potential applications in different areas like Construction industry, structural fills and highway embankment. Pond ash differs from fly ash collected from Electrostatic precipitators in a dry form in that it contains significant amount of relatively coarser particles (greater than 45 μm and up to 150 μ m). Due to its low pozzolonic nature it has potential to be used as supplementary 2 and alternative material in construction industry in place of sand which now a days is of scarce availability. It is of prime importance to carry out research works on the feasibility of using alternative materials like Pond Ash, a waste by product and its suitability for potential utilization in concrete constructions, which can replace sand partially or fully as an alternative construction material contributing to sustainability and reducing burden on environment. Concrete is the most used construction material across the world and in concrete maximum part is

Coarse Aggregate and Fine Aggregate. Hence, if pond ash used as at least partial replace with fine aggregate than it will reduce cost of concrete production. Pond ash is needed from the view of point of experimental preservation and effective utilization of resources. However, information about pond ash using in concrete as fine aggregate with partial replace with pond ash is still insufficient so it will be an advisable to get more details about the characteristics of concrete using pond ash. Use of pond ash in concrete will not only result in conservation of natural aggregate but also solve the problem of disposal of huge quantity of pond ash produced regularly and kept in abundance.

II. Historical Back Ground And Source Of Pond Ash

India's major source of power generation is through thermal power plants. These thermal plants require coal as a fuel for power generation. During the process of power generation fly ash and bottom ash is produced. Lot of research has been done on utilization of fly ash but very little emphasis is given on pond ash. The finer fraction of the ash, called as fly ash, gets collected in the electrostatic precipitators (ESP) while the ash that is collected at the base of the boiler is called as bottom ash. In India, the fly ash and bottom ash are mixed with water and dumped in ponds called as pond ash. The ash lying in ponds occupy more than 40000 hectares of land, which otherwise would have been fruitfully used for developmental purpose. The chemical, mineralogical and physical properties of the ash lying in ponds vary because of non-standardization of thermal power plant equipment and variable quality of coal. Ash is the residue after combustion of coal in thermal power plants. Particle size of the ash varies form around one micron to around 600 microns. The very fine particles (fly ash) collected from this ash generated by electro static precipitators are being used in the manufacture of blended 3 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 known as pond ash. Among the industries, thermal power plants are the major contributor of pond ash. Be sides, this steel, copper and aluminum plants also contribute a substantial amount of pond ash. During the combustion of pulverized coal at the thermal power station the product formed are bottom ash, fly ash and vapors. The bottom ash is that part of the residue which is fused into particles and is collected at the bottom of the furnace. The ash obtained from the ESP is presently utilized in cement, concrete, brick manufacturing and for refilling low lying areas. Pond ash being coarser and less pozzolonic is not being used, or more importantly in places where the fine aggregate is contaminated with harmful chemicals such as sulphates and chlorides and pond ash accumulation posing environmental problems. The partial replacement of sand by pond ash in concrete is attempted. It is found that it is possible to use only pond ash as fine aggregate without compromising on strength and durability. This study opens up a major avenue for utilization of pond ash.

III. Need For The Partial Replacement Of Sand By Pond Ash

An increased demand for river sand as fine aggregate in the construction industry has resulted in the reduction of resources and an increase in cost. Under such circumstances, the pond ash which is a residue and by-product of thermal power plant can be used as an economic alternative to the natural sand. Ash is produced as a by-product which is an Industrial waste. This ash is of different forms such as Fly ash, Bottom ash and Pond ash. A major problem arises on the disposal of this industrial waste. As days go on more coal is utilized and more ash is made ready for the disposal, so this becomes a serious problem. These industrial wastes are to be utilized in different fields such as construction and etc…, to minimize its disposal problems also. Natural sand is commonly used as fine aggregate in concrete. There is scarcity of natural sand due to heavy demand in growing construction activities which forces to find the suitable substitute, also due to extensive construction activity natural sand is becoming expensive and scarce. The purpose of this study is to investigate the possibility of using alternative fine aggregates such as Pond ash. The disposal of fly ash will be a big challenge to environment, especially when the quantum increases from the present level to high. Hence worldwide research work was focused to find alternative use of this waste by product and its use in concrete industry is one of the effective methods of utilization in proper manner. Increase in demand of fine aggregate 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 for work. Disposal of coal fly ash in open and unlined ash ponds causes serious adverse environmental impacts due to its elevated metals concentrations and it's leaching into soils and groundwater.

II. LITERATURE REVIEW

Lee bong chun, Kim jin sung, Kim tae sang, Chae seong tae- 2008 [1] In this paper mechanical properties and durability properties of the concrete were analysed by replacing pond ash a part of fine aggregate in 10, 20, 30% by weight.

For the present investigation pond ash was collected from three different pits and mixes were prepared. Physical and chemical properties of samples were checked by various tests, SEM analysis showed that, fineness modulus of pond ash varied from 2.19-3.26, absolute volume varied from 50.34-62.25%, surface dry density and unit volume of pond ash varies from 1.85-2.27 and 0.93-1.342 g/cm3, absorptiveness of pond ash was in range between 3.77 and 5.78% due to porous nature. Pond ash concrete was lighter than normal concrete and workability of pond ash incorporated concrete was low at 30% pond ash content. Compressive strength and tensile strength increased with increase in pond ash content it was explained that this might be because of less w/c ratio which is caused by absorption of mixing water by pond ash

XRD test on pond ash showed that, pond ash has major crystalloids as quartz and mullite. Pond ash has high chloride content and need to be removed to use in concrete. Freezing and thawing resistance of concrete decreased with increases in pond ash content it aws explained that this was because of air content and water absorption of pond ash.

LB Andrade, JC Rocha, M cheriaf-2006[2] In this paper moisture movement was studied to know whether pond ash was suitable to replace as suitable as fine aggregate and evaluation of behavior of concrete using bottom ash as replacement to natural sand was done. Five blends with 0%, 25%, 50%, 75% and 100% replacement to natural sand by bottom ash were prepared; two concrete mix proportions were made CRT3 and CRT4. CRT3 mixes with considering water content in the bottom ash at the time of concrete production, CRT4 with discounting the water content and considering all contents as solid materials. Capillary absorption: increase in final water content was directly dependent on increase in pond ash content, porosity of pond ash results in greater capillary absorption this is also influenced by absorption of bottom ash particles itself. Final moisture content was almost triple for 50% increase in porosity of blend. Grain size of bottom ash also adds to increase in moisture content. Bleeding: CRT3 and CRT4 mixes had almost same water loss. Since pond ash absorbed more water loss of water from mixes was also directly dependent on pond ash content. Water loss through air drying: when samples were kept to dry water was lost from samples water loss increased with increase in pond ash content of the mixes.

BHARATIGANESH, H SHARADABAI, R NAGENDRA-2009[3] In this paper workability and strength properties of M20 concrete with various levels of replacement to fine aggregates by pond ash is studied. Five mixes were designed M20 NC, M20 12.5%, M20 25%, M20 37.5%, M20 50%. M20 NC represents normal concrete with 0% replacement to natural sand. M20 12.5% represents concrete mix with replacement to natural sand by pond ash of 12.5%. M20 25% represents concrete mix with replacement to natural sand by pond ash of 25%. M20 37.5% represents concrete mix with replacement to natural sand by pond ash of 37.5%. M20 50% represents concrete mix with replacement to natural sand by pond ash of 50% .The results show that as the quantity of pond ash or replacement level increases mix becomes harsh, slump decreases and admixture dosage also increases. Compressive strength of M20 25% was found to be maximum and compressive strength of M20 50% decreases by 0.92 times to that of M20m NC. 25% replacement level was found to be optimum. Split tensile strength of M20 12.5%, M20 25%, M20 37.5%, was found to be higher than that of M20 NC but split tensile strength of M20 50% was less than M20 NC. Flexural strength of M20 12.5%, M20 25%, M20 37.5% was found to be more than that of M20 NC and was found maximum at 25% replacement level.

Bharatiganesh, Dr. R. Nagendra, Dr. H. Sharadabai, MR Suresh, Harisha C, Krishna KL-2009[4] In this paper self compacting concrete with cementatious material 400kg/m3 and fine aggregate i.e. manufactured sand was replaced with pond ash for different steps i.e. 10%, 20%, 30%, 40%, 50% and fresh properties were studied. Results showed that slump flows were comparable with that of normal self compacting concrete, no specific pattern was observed in T50 sec but satisfied EFNARC specifications. V-funnel time increased with increase in replacement levels of pond ash, paper states that this effect may be the result of finer particles in pond ash. L-box test results for all replacement level were satisfying to EFNARC specification. In this paper it is also explained that pond ash replaced SCC was found viscous with higher replacement levels, this property of pond ash SCC was related to the fineness of pond ash particles and vesicular texture of pond ash particles. Compressive strength of the mixes reduced with increase in replacement level for 50% replacement level 25% reduction in strength was observed for same curing period.

SM Waysal, PD Dhake, MP Kadam[5] In this paper experiment was conducted by replacing natural sand with pond ash by weight at various steps of replacement. Cement content was kept constant as 400kg/m3 and water content 192 liters. Mechanical properties were checked. Results of the test showed that at 20% replacement of sand compressive strength increased as that of normal concrete

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up to 40% thereafter compressive strength decreased. Paper also states that strength gain in pond ash concrete is slow. Split tensile strength of 7 days increases for 20% to 40% replacement levels and after those strength decreases, for 28 days strength increased for 20% replacement and then decreased with increase in percentage of replacement. Flexural strength also increased for 20% replacement level and thereafter decreased. Modulus of elasticity increased up to 20% replacement later it decreased.

Debashis Das, V.K Gupta, S.K Kaushik[6] In this paper 12 mixes are prepared, 4 mixes with 10mm maximum size of coarse aggregates, 4 mixes with 12.5mm as maximum size of aggregates and 4 mixes with 20mm as maximum size of aggregates, all the parameters were kept constant other than coarse aggregate and fine aggregate, initially coarse aggregate were taken 60% of total aggregate and after that coarse aggregate was replaced by sand in step of 15%. Results of the test showed that mixes with 60% coarse aggregate showed unsatisfactory slump and high segregation. Later to reduce segregation and improve workability one fourth of coarse aggregate was replaced with fine aggregates with maximum size of coarse as 10mm and 12mm flow ability and segregation resistance improved. In second step two parts of coarse aggregate was replaced with sand, the ratio CA: FA was 30:70 flow was uniform without segregation. In third step two third parts of coarse aggregate was replaced with fine aggregate flow was uniform without segregation but flow diameter was only 60cm, from above results it showed that for 30% coarse aggregate by weight results were quite good.

III.EXPERIMENTAL ANALYSIS

The experimental program was designed to evaluate the mechanical properties i.e. compressive strength, Flexural strength, Splitting Tensile strength of concrete and Durability Properties such as Water absorption , Sorptivity , Permeability & Acid Attack for M40 & M50 grade concrete with different percentages of Fine aggregate replaced by Pond Ash. The problem consists of casting and testing of Total 260 Specimens. The specimen of standard cubes (150mmx150mmx150mm), Cylinders (150mmx300mm height) (100mx50mm height) & (100mmx100mm height), Prisms (100mmx100mmx500mm) were casted with and without partial replacement of Fine aggregate (sand) by pond ash. Universal testing machine was used to test all the specimens. In the first series the specimens were casted with M40 grade concrete with different levels of replacement of fine aggregate by pond ash (0%, 15%, 20%, 25% and 30%). In second series the specimens were casted with M50 grade concrete with different levels of replacement of fine aggregate by pond ash (0%, 15%, 20%, 25% and 30%).

Materials

A. Cemen
B. Fine aggregate (Sand
C. Coarse aggregate
D. Pond ash
E. Super plasticizer- FOSROC Conplast SP-430

The cement used in this investigation is ordinary Portland cement (Barati Cement) 53 grade was used confirming to IS: 12269 – 2013 and Specific gravity is 3.15. The fine aggregate conforming to zone III according to IS 383:1970 was used. The specific gravity of the sand used was 2.68. The coarse aggregate conforming to IS 383:1970 and specific gravity is 2.59 was used and Maximum coarse aggregate size used is 20 mm. Pond ash is collected from NTPC Ramagundam and laboratory study was carried out for salient characteristics of such Sieve Analysis, Specific Gravity, Water absorption and Bulk Density.

Table I. Physical properties of Pond Ash

1.	Specific gravity	2.10
2.	Bulk density	1020 kg/m3
3.	Fineness modules	2.28
4.	Water Absorption	10%

IV. CASTING PROGRAMME

Casting programme consists of preparation of moulds (as per IS 10086:1982), preparation of materials, weighing of materials and casting of cubes, cylinders, beams. Mixing, compacting and curing of concrete are done according to IS 516:1959. The cubes which are intended for self-curing

are kept in in-door/shade at room temperature. Materials required for the mix is as shown below in Table II.

Table II. Proportions of constituent of materials

S. No	Grade of Mix	Water Cement Ratio	Proportions of constituent of materials		
			Cement	Fine aggregate	Coarse aggregate
1.	M40	0.40		1.468	2.518
2.	M50	0.35		1.252	2.423

V. EXPERIMENTAL INVESTIGATIONS

A. Strength properties

The casted specimens were then tested on Universal Testing Machine (UTM) with a weight of 3000 kN as per IS 516:1959 after 28 days of curing. Both the specimen and the bearing surface of the UTM were cleaned from dirt to obtain a proper bond between the two surfaces when load is applied. The specimen is then placed in UTM in such way that the smoother sides of the cube facing the load applying axis. The axis of the specimen was carefully aligned to make it coincide with the centre of loading frame. The load was increased with a constant rate until the load resistance capacity of the specimen is lost completely. The maximum load the specimen can withstand is recorded. This process is repeated for all the mix design specimens. Compression testing machine of capacity 3000 kN was used to test cylindrical specimens. The

preparation process for the cylindrical specimens is similar to the cubical specimens. The maximum load in which the specimen can sustain is then recorded. The beam specimens were also prepared for testing according to the procedure mentioned before. Two-point loading was used to generate bending moment on the specimen. Both the loads were increased at a constant rate until the specimen is no longer able to sustain any more loading. The maximum load applied on the specimen is recorded. The maximum load the cube, cylinder and the beam can withstand are then utilised for calculation of average compressive strength, Split tensile strength and flexural strength respectively.

B. Durability properties

Sorptivity test is a very simple technique that measures the capillary suction of concrete when it comes in contact with water. The Sorptivity test was performed in accordance with the ASTM C 1585 [11]. This test is used to determine the rate of absorption (Sorptivity) of water by measuring the increase in the mass of a specimen resulting from absorption of water as a function of time when only one surface of the specimen is exposed to water ingress of unsaturated concrete by capillary suction during initial contact with water. The rate of sorption is the slope of the best-fit line to the plot of absorption against square root of time. Sorptivity specimens were prepared by cutting a disc of 100 ± 6mm diameter with 50±3mm length. The cumulative water absorption (per unit area of the inflow surface) increases as the square root of elapsed time (t).

Mass gain due to sorption will be measured at definite intervals for the first six hours.

$S = (Q/A)\sqrt{t}$

Where Q = water absorbed in cm3

A = surface area in contact with water in cm2

t = time in sec

S = sorpitivity in mm/√s

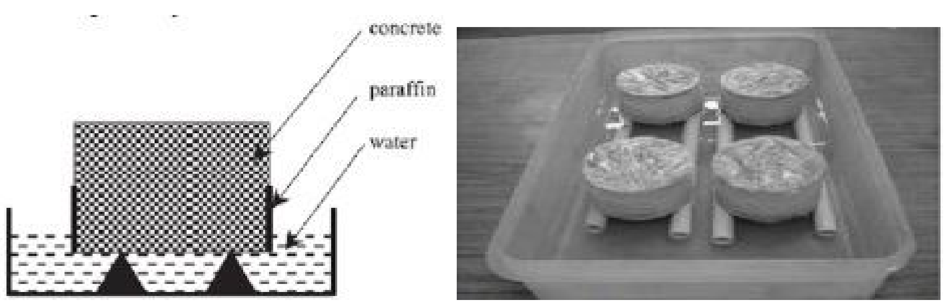

Fig 1. Sorptivity test

Concrete is susceptible to attack by sulfuric acid produced from either sewage or sulfur dioxide present in the atmosphere of industrial cities. The hardened cement paste binder in concrete is alkaline, and therefore no Portland cement concrete can be considered acid resistant. However, it is possible to produce a concrete that is adequately durable for many common circumstances

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by giving attention to low permeability and good curing. In these circumstances, acid attack is only considered significant if the pH of the aggressive medium is less than about 6.

The chemical resistance of the concrete is studied through chemical attack by immersing concrete blocks in Sulphuric acid (H2SO4) solution. After 28 days of self-curing immerse the specimens in 5% sulphuric acid solution. After removing the specimens from the solution, clean the surfaces with a soft nylon wire brush under the running tap water to remove weak products and loose material from the surface. Then allow the specimens to surface dry and measure the masses and determine the compressive strength.In acid attack test weight loss, reduction compressive strength is determined to evaluate the extent of concrete deterioration due to sulphuric acid attack. One method of estimating the durability of a porous material is by measuring the rate at which a fluid, gas or liquid permeates through the material under a given head of pressure (Permeability). Therefore, the measurements of the permeability of concrete were used as an indication of durability. The more quickly a fluid moves through the material (higher permeability), the lower anticipated durability. Similarly, if a fluid moves through the material at a very slow rate (low permeability), a high durability would be expected. Permeability is the key to all durability problems. Permeability of concrete can be measured by the automatic concrete water permeability device on cylinders of dimensions (150 × 150 mm) as shown in Fig 4. The sides of the specimen are sealed with epoxy and water under pressure is applied to the top surface only. The device applies a hydrostatic water pressure of 10kg/cm². The water permeated through specimens is directly collected and measured in a graduated cylinder. By knowing the hydrostatic pressure, duration, specimen dimensions, and the permeated amount of water, it is possible to determine the permeability coefficient in cm/sec by applying Darcy's law:

$$K = \frac{Q \times H}{A \times T \times P}$$

Where: Q = permeated water, cm 3
H = height of the specimen, cm
A = surface area of the specimen, cm2
T = test time, sec P = water head, cm

VII. RESULTS AND DISCUSSIONS

Series of test were carried out on the concrete specimens to obtain the strength and durability characteristics of pond ash concrete.

TABLE III. Strength properties

Mix Designation	Replacement of Pond Ash	Avg. compressive strength (N/mm2)		Split tensile strength (N/mm2)		Flexural strength (N/mm2)	
		28days	% increase	28days	% increase	28days	% increase
M40							
M1	0%	45.15	–	3.181	–	4.957	–
M2	15%	50.96	5.85	3.350	5.32	5.196	4.83
M3	20%	52.15	8.31	3.477	9.31	5.515	11.26
M4	25%	48.89	1.54	3.242	1.92	4.97	0.27
M5	30%	46.07	-4.31	3.049	-4.14	4.279	-13.67
M50							
M6	0%	58.37	–	3.430	–	5.449	–
M7	15%	60.44	3.55	3.542	3.29	5.661	3.90
M8	20%	63.11	8.12	3.740	9.04	6.00	10.24
M9	25%	58.81	0.76	3.369	-1.78	5.542	1.71
M10	30%	56.44	-3.30	3.138	-8.49	5.103	-6.34

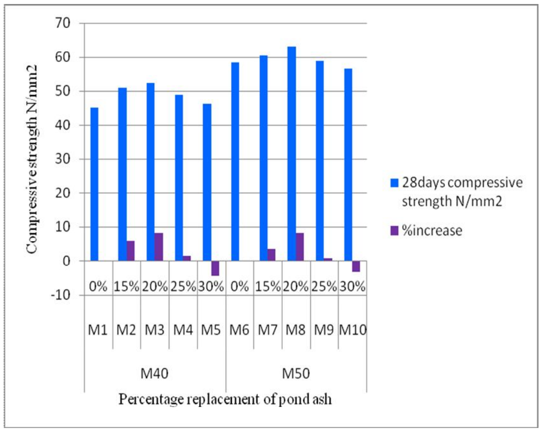

Fig:2 Comparison Of Compressive Strength

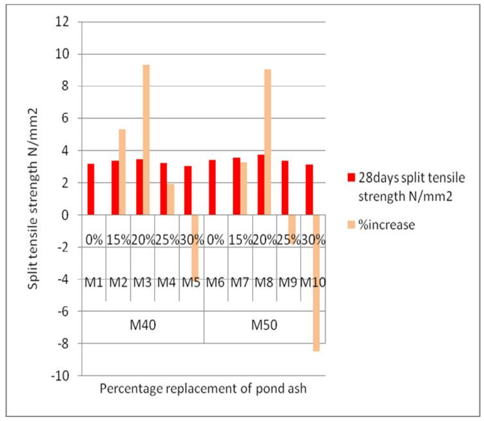

Fig:3 Comparison Of Split Tensile Strength

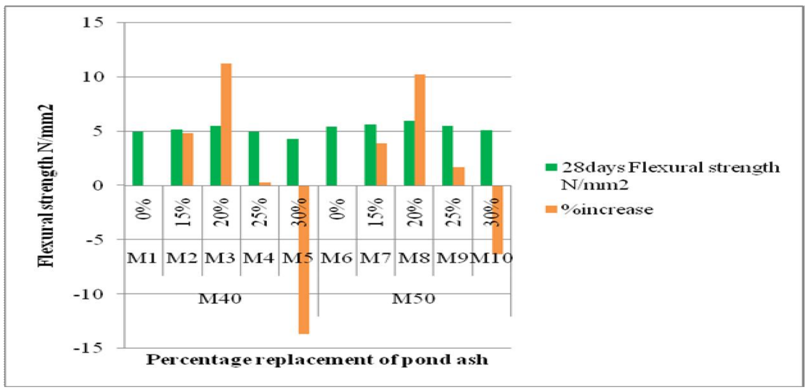

Fig:4 Comparison of flexural strength strength

It is observed that on addition of pond ash up to 20% partial replacement of fine aggregate comparable increased in compressive strength is achieved at all ages as compared to the conventional concrete. However the compressive strength is maximum at 20% replacement level. At this replacement level the compressive strength is 5.45%, and 8.31% higher than the conventional concrete at 7 and 28 days for M40 grade concrete and 4.48% and 8.12% higher than the conventional concrete at 7 and 28 for M50 grade concrete respectively. The increase in compressive strength is due to the fact that pond ash being pozzolanic material reacts with free lime present in OPC and produce C-S-H gel, which has good binding properties thereby increase the compressive strength in general. Another reason of increase in compressive strength may be packing of voids in concrete by pond ash particles.

TABLE IV. Durability properties

Mix Designation	Replacement of Pond Ash	Sorpitivity I(mm x 10^{-3})	Permeability Cm/sec x 10^{-} □	% reduction of compressive strength due to acid attack
		M40		
M1	0%	0.0648	0	9.24
M2	15%	0.0738	0	10.46
M3	20%	0.0825	0	14.50
M4	25%	0.0988	2.65	16.36
M5	30%	0.1122	5.80	17.99

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M50				
M6	0%	0.0533	0	10.40
M7	15%	0.0713	0	13.47
M8	20%	0.0854	0	15.96
M9	25%	0.0966	0	14.61
M10	30%	0.1285	2.21	16.27

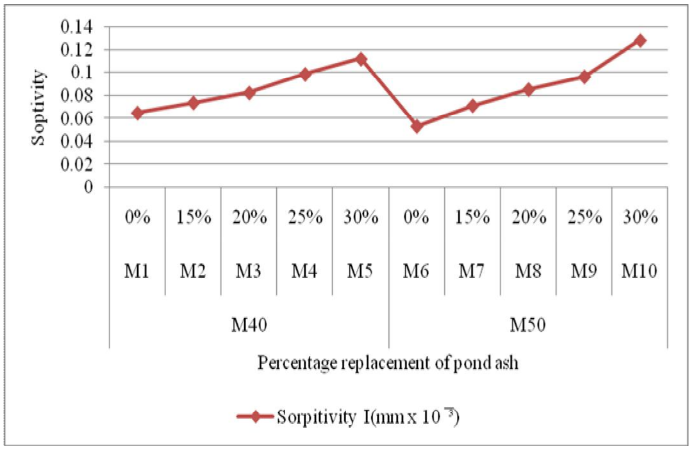

Fig:6 Comparison of Soptivity

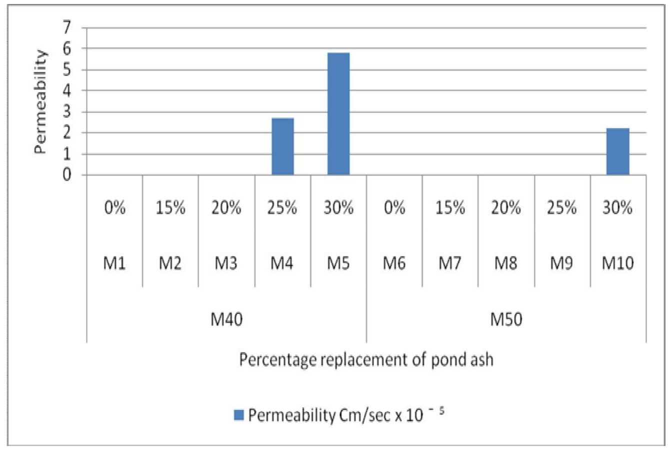

Fig:6 Comparison of Permeability

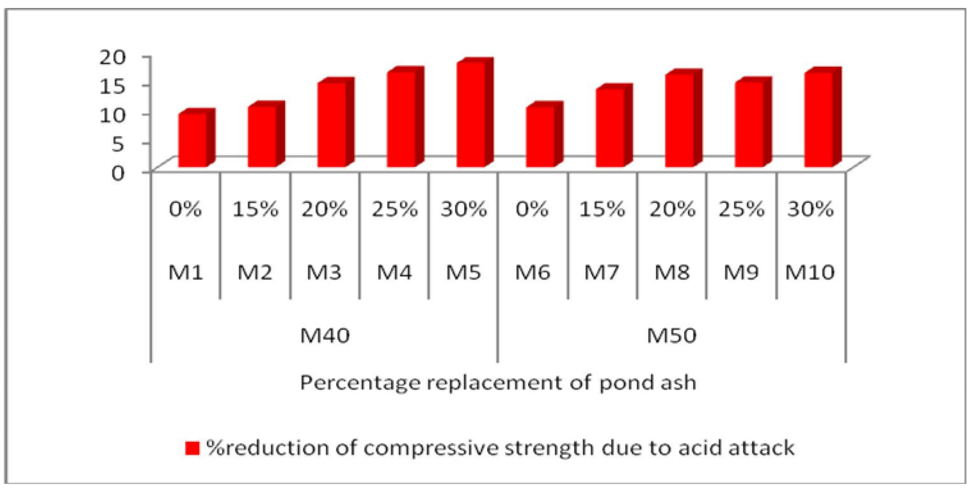

Fig:6 Comparison of Resistance to acid attack

The Sorptivity curve was found to be higher compared to that of conventional control concrete. The rate of absorption, which has significant effect on durability property of concrete, was found more in Pond ash concrete than the conventional concrete.Minimum and maximum values of Sorptivity for M40 and M50 grade Pond Ash concrete are 0.0648 mm/min1/2 , 0.1122 mm/min1/2 and 0.0533 mm/min1/2, 0.1285 mm/min1/2 respectively. From the results it is showing that coefficient of permeability for M40 grade concrete the percentages of replacement of pond ash up to 20% is nil and beyond that coefficient of

permeability is 2.65x10-5 cm/sec and 5.80x10-5 cm/sec for 25% & 30% replacement levels of pond ash and coefficient of permeability for M50 grade concrete the percentages of replacement of pond ash up to 25% is nil and beyond that coefficient of permeability is 2.21x10-5 cm/sec for 30% replacement level of pond ash respectively. The acid attack test on concrete cube was conducted by immersing the cubes in the acid water for 28 days, after 28 days of curing. Sulphuric acid (H_2SO_4) with pH of about 2 at 2% weight of water was added to water in which the concrete cubes were stored. The pH was maintained throughout the period of 28 days. After 28 days of immersion, the concrete cubes were taken out of acid water. Then, the specimens were tested for compressive strength. The resistance of concrete to acid attack was found by the % loss of weight of specimen and the % loss of compressive strength on immersing concrete cubes in acid water. It is observed from the results percentage loss in weight and percentage reduction in compressive strength due to Acids is increased when percentage of replacement level is increased. Maximum percentage loss in weight and percentage reduction in compressive strength due to Acids for M40 grade concrete are 2.16%, 17.99% at 30% Replacement of sand by pond ash and the minimum percentage loss in weight and strength are 1.22%, 9.24% at 0% replacement of Pond ash and maximum percentage loss in weight and percentage reduction in compressive strength due to Acids for M50 grade concrete are 2.07%, 16.27% at 30% . Replacement of sand by pond ash and the minimum percentage loss in weight and strength are 1.24%, 10.40% at 0% replacement of pond ash.

VIII. CONCLUSIONS

This research work is taken up to determine the mechanical and durability properties of Pond Ash concrete by replacing fine aggregate (partially or fully) with pond ash for structural application. Based on the investigations, the following conclusions are made.The workability of the concrete mix decreases with increased percentage of pond ash. The reason is due to higher surface area of the pond ash, which absorbs higher water content compared to natural fine aggregate. It is observed from results that the compressive strength of concrete increases only up to the 20% of natural sand by pond ash, beyond that it decreases with increase in the percentage of fine aggregates replacement with the pond ash. The 7 and 28 days compressive strength of M40 and M50 grade Pond ash concrete is 5.45%, 8.31% and 4.48%, 8.12% higher than the conventional concrete. The test results of splitting tensile strength and Flexural strength of Pond ash concrete gradually increases for 20% replacement with natural fine aggregates, beyond that, strength is decreased. It is observed that, 7 and 28 days splitting tensile strength of M40 and M50 grade Pond Ash concrete is 7.89 %, 9.31% and 7.48%, 9.04% higher than the conventional concrete.Flexural strength of 7days and28 days of M40 and M50 grade Pond Ash concrete is 8.98%, 11.26% and 8.52%, 10.24% higher than conventional concrete. Replacement of natural fine aggregates with Pond Ash at 20% is very satisfactory and encouraging for production of Pond Ash concrete for structural applications. The water absorption of M40 and M50 grade pond ash concrete is 51.01% and 36.86% higher than the conventional concrete. This can be mitigated by using higher water reducing agents (Super Plasticizers).The water absorption of all mixes was lower than 5%, which can be classified as 'low'.Mixes remained acceptable. The Sorptivity of pond ash concrete shows higher Sorptivity than the conventional concrete Minimum and maximum values of Sorptivity for M40 and M50 grade Pond Ash concrete are 0.0648 mm/min1/2 , 0.1122 mm/min1/2 and 0.0533 mm/min1/2, 0.1285 mm/min1/2 . As long as the values were less than 0.2000 mm/min1/2, the mixes remained acceptable for concrete. Coefficient of permeability for M40 grade Pond ash concrete up to 20% replacement of natural fine aggregates with pond ash is nil. Coefficient of permeability for M40 grade Pond Ash concret is 2.65x10-5 cm/sec and 5.80x10-5 cm/sec at 25% & 30% replacement of natural fine aggregate with pond ash. Coefficient of permeability for M50 grade Pond Ash concrete is nil up to 25% replacement of natural aggregates with pond ash. It is 2.21x10-5 cm/sec at 30% replacement of natural fine aggregates with pond ash.The water permeability test revealed the concrete has 'good' quality, judging from the coefficient permeability in the range of 0 to 5.80x10-5 cm/sec. It is observed that, the percentage loss in weight and percentage reduction in compressive strength of concrete increases with increase in percentage of pond ash due to Acids. Maximum percentage loss in weight and reduction in compressive strength due to Acid attack for M40 & M50 grade pond ash concrete are 2.16%, 17.99% and 2.07%, 16.27% at 30% replacement of natural fine aggregate with pond ash. Minimum percentage loss in weight and strength are 1.22%, 9.24% and 1.24%, 10.40% at 0% replacement of natural fine aggregates with Pond ash for M40 and M50 grade concretes respectively. All the experimental data of test results shows that the replacement of Industrial wastage (Pond Ash) improves the mechanical properties of concrete. Durable Pond Ash concrete can be produced by replacing natural fine aggregate with Pond Ash. From this experimental investigation, it is concluded that, the natural fine aggregate can be 20% replaced with Pond Ash.

IX. SCOPE OF THE FUTURE WORK

Based on the present investigation, the scope for the future work is given below:

A. In future the flexural strength of beams may be observed by increasing the sizes of beams.
B. The part replacement of fine aggregate with pond ash for casting the slabs with different end conditions may be required for the required strength values.
C. Also by providing different types of increased reinforcements the flexural strength of beams may be observed.Shear strength & Behavior of beams may be observed by increasing the sizes of beams.
D. Some mechanical properties such as (creeping & abrasion) should be studied.

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