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Partial Replacement of Fine Aggregates in Cement Mortar by using Pond Ash and Development of Low Cost Tiles

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Abstract

Pond ash is squanders and waste product of Thermal force plant, have been acquainted into Indian solid industry with save common assets of elements of cement. In India, a large portion of the Thermal force plants embrace wet technique for debris removal. Lake debris is gathered from Thermal force plant at the base, in that it contains critical measure of generally coarser particles (crossing from 150 microns to 2.36 mm). Lake debris usage assists with diminishing the utilization of normal assets. Additionally it is help to take care of the issue of removal of Pond debris since it contains enormous measure of substance mixes, for example, SiO_2, Al_2O_3 and so on. These synthetic mixes (SiO_2, Al_2O_3) are assumes a significant job in hydration response and assists with delivering bond between two nearby particles. Utilization of Pond Ash in concrete is a significant eco productivity drive. It is important to locate the specific appropriate rates of lake debris so it is chosen to use in differing rate as 0%, 5% 10%, 15%, 20%, 25%, 30%. Also, to check the properties of new concrete and solidified cement, for example, droop and compressive quality, rigidity, flexural quality individually. Likewise solid assumes a significant job in long life time of structure so it is additionally critical to check impact on strength by utilizing sulfate assault, chloride particle entrance, drying shrinkage. Study shows the essential properties of Pond ash. It likewise contrasts these properties and characteristic sand. Fractional substitution doesn't bring on any unfavorable impact on properties of new concrete. The outcome shows that solid invigorating great with fractional substitution of fine total. Just as Pond debris is the acceptable whenever utilized as filler material in concrete. Subsequently, it is appropriate to utilize lake debris as fine total or halfway supplanting with normal sand.

Keywords: Pond ash • Concrete • Natural recourses • Wet method • SiO_2 • Al_2O_3• Hydration bond • Eco friendly • Compressive • Tensile • Flexural • Durability • Sulphate chloride

Introduction

Waste and results have been acquainted into Indian solid industry with preserve characteristic assets and condition just as to lessen the expense of cement [1]. For instance, fly debris, a side-effect from warm force plants, has been generally utilized in Indian solid businesses as a pozzolanic material for supplanting a piece of concrete because of its principle benefits on functionality and strength. Using side-effects to supplant regular totals is another elective answer for accomplish natural protection just as to acquire a sensible solid expense.

Unused fly debris and base debris (buildup gathered at the base of heater) are blended in slurry structure and stored in lakes which are known as lake debris [2]. Lake fly debris and contains moderately coarse particles. The coal fly cinders contain harmful metals in a lot higher focuses that are discharged into the earth by warm force plants dependent on coal ignition. Base debris is the ally to fly debris in procedure of coal-igniting with an inexact measure of 20 % by volume of the all-out debris, contingent upon the sort of kettle, dust assortment framework, consuming temperature and the kind of coal. Its molecule is permeable, unpredictable, and coarser than that of fly debris however its substance sythesis isn't vastly different [3]. A few examinations on the use of base debris in concrete had been centered on its capability to supplant or incompletely supplant fine total because of its comparable molecule size to that of typical sand [4]. Different endeavors to apply base debris as a pozzolanic material had additionally been accounted [5]. The fly debris created every year in India, with an expected measure of 110 million tons (Central Electricity authority of India) [6], has been generally dumped in landfill locales. However, fly debris had been demonstrated to improve different properties of Concrete. In this examination work an endeavor is made to discover the chance of utilizing lake debris in regular cement. The piece of the sand is supplanted by lake debris in various organizations and the solid is made in traditional strategy.

A large portion of the Thermal Power plants in Indian embrace wet strategies for removal and capacity of the debris in enormous lakes and dykes. In the wet strategy, both the fly debris gathered from electrostatic precipitators and the base and mesh debris are blended in with water and moved to the lakes in a slurry structure. Lake debris is being created at a disturbing rate and endeavors are required to securely arrange it and if conceivable discover methods of using it. Fly debris gathered through containers has been broadly acknowledged as pozzolonic and is being utilized by the development business. Lake debris being coarser and less pozzolonic isn't being utilized, or all the more critically in places where the fine total is polluted with destructive synthetic concoctions, for example, sulfates and chlorides and lake debris gathering presenting natural issues. The incomplete substitution of sand by lake debris in concrete is endeavored. It is discovered that it is conceivable to utilize just lake debris as fine total without settling on quality and sturdiness. This investigation opens up a significant road for usage of lake debris.

With a developing substance of lake debris, there has been are generally more noteworthy increment in compressive quality, contrasted with typical cement, and such pattern may be an outcome of diminished water/concrete proportion incited by the retention of blending water [7-10]. The reason for this examination is to research the chance of utilizing elective fine totals, for example, Pond debris. The removal of fly debris will be a major test to condition, particularly when the quantum increments from the current level to high. Thus overall research work was engaged to discover elective utilization of this loss by item and its utilization in solid industry is one of the viable techniques for use in appropriate way. Increment sought after of fine total and decline in normal asset of fine total for the creation of cement has brought

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about the need of recognizing another wellspring of fine total. It is likewise essential to consider the impact of this fractional substitution of sand on concrete, to locate the ideal substitution of fine total. Vitality age is expanding step by step because of quick industrialization. Vitality age through warm force plants is exceptionally average now days. Lake debris from these warm plants is accessible in huge amounts. Lake debris usage assists with decreasing the utilization of characteristic assets. In current time common sand are utilizing and an it is exorbitant so it's require to supplant by Pond Ash. Utilization of elective material in cement, for example, modern side-effect coal Ash (Fly Ash and Pond Ash) is a significant eco productivity drive. It is likewise the social obligation of scientists to empower the "advantageous utilization of mechanical side-effects so as to safeguard assets, preserve vitality and decrease or kill the requirement for removal of modern waste in landfills. This exploration paper reports the essential properties of Pond debris. It additionally contrasts these properties and characteristic sand. Fundamental changes in both sort of total properties were controlled by different test according to require IS code, in this way; it is a reasonable to utilize lake debris as fine total or incomplete supplanting with normal sand. Concrete is a development material made principally out of Cement, Fine Aggregate (Sand), Coarse Aggregate, Water.

Coal-based thermal power plants are the major source of power generation in India and coal ashes are the by-products of these thermal power plant. Fly ash mixed with water and pumped out in slurry form to large pond, known as pond ash.

Objectives:

- To use pond ash as fine aggregate in mortar
- To effect of pond ash in cement mortar
- To compare other fine aggregates
- Development of floor tiles

Pond ash

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 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 [2]. 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.

Advantages of use of pond ash

Following are the main advantages of Pond ash while using in Concrete.

1. Use of Pond ash as partial replacement of Sand is Eco-friendly drive.
2. Pond ash acts as filler material as well as bonding agent as it shows the bonding property also.
3. Use of pond ash in concrete can save the thermal industry disposal costs and produces a ‘greener’ concrete –for construction.
4. Environmental effects from wastes and residual amount of cement manufacturing can be reduced through this way.
5. Pond ash can be used to form various higher concrete grades.
6. The cement content can be reduced a lot by increasing the fly ash content to make it more economical and also we can achieve designed compressive strength.
7. Use of Pond ash as partial replacement of Sand is help to solve issue of ash disposal.
8. Use of pond ash is good Option for natural Sand.
9. Partial replacement of natural sand is does not change original strength of concrete.
10. Manufacturing of cement mortar also possible.
11. The cement content can be reduced a lot by increasing the fly ash content to make it more economical and also we can achieve designed compressive strength.
12. The quantity of pond ash is available enormously at thermal power stations at free of cost.
13. It is easy to investigate the properties of pond ash.
14. When pond ash is used in brick construction the compressive strength of brick is increase with increase in lime content.

Limitations of study

As the famous phrase says that, every coin has two sides. Till this moment we saw only the easy way of use of pond ash as replacement of natural sand but from the another side there are some limitations on such replacement. This study is work on the concept of partial replacement of sand (one of the important ingredient of concrete) by pond ash (waste byproduct of thermal power plant), with different proportions.

The investigation of previous research paper shows that, if the partial replacement of sand exceeds some limit that affects the properties of concrete on large scale, it will prove dangerous or it is not possible to use such concrete practically.

While adding pond ash in concrete it will need skilled supervision. At the time of replacing the sand in concrete, it is very important to replace the sand in desired proportions only, therefore it is required skilled supervision. This is also one of the limitations of this study. This replacement is suitable only for mass concreting projects as like construction of dam structures. This partial replacement is not economical if the concreting is on small scale.

Also pond ash may not available easily; availability of pond ash depends upon the distance of construction site and ash ponds. The CaO content is less in the pond ash so that the plasticizer property of pond ash is decreased. Hence, the compressive strength is decreased (after some limit only). The water absorption of pond ash is on large scale and is generally dependent on which type of coal is used in its manufacturing. Pond ash cannot be used in large proportions for replacement [8]. While the pond ash is used the workability is reduced. For obtaining the required workability, super plasticizers are added while preparing the concrete [9].

Research Methodology

This study investigates the interpretation of tests results on concrete in which fine aggregate (natural sand) is partially replaced by pond ash. Pond ash is wastes and by-products of Thermal power plant, have been introduced into Indian concrete industry to conserve natural resources of ingredients of concrete. In India, most of the Thermal power plants adopt wet method of ash disposal. In wet method of disposal of ash, bottom ash and fly ash are mixed with water and the slurry is disposed on vacant land to reduce the excess water from that slurry. After the drying of that slurry clinkers are formed and that can be collected as Pond ash. Sometimes it becomes the problem of such ash disposal because it requires the large vacant land to disposal of ash. Bottom ash is collected from Thermal power plant at the bottom, in that it contains significant amount of relatively coarser particles (spanning from 150 microns to 2.36 mm). Pond ash utilization helps to reduce the consumption of natural resources. Also it is help to solve the problem of disposal of Pond ash because it contains huge amount of chemical compounds such as SiO_2, Al_2O_3 etc. These chemical compounds (SiO_2, Al_2O_3) are plays an important role in hydration reaction and helps to produce bond between two adjacent particles. Also sand does not use only to fill gap between two particles of aggregate but also to increase the volume of concrete. Pond ash plays this both role very well.

Thermal Power Plants using coal is chief source of energy in our country

and it is likely to remain so in near future. The total production of fly ash per annum has already crossed 100 million tones and the disposal of the fly ash is causing several challenges. Utilization of fly ash has picked up but till the percentage utilization is far below satisfaction and power plants are no option but to dispose the fly ash in ash pond.

Pond ash is cheaply available and is available on large scale. Use of Pond Ash in concrete is an important eco efficiency drive. It is necessary to find the exact suitable percentages of pond ash so that it is decided to use in varying percentage as 0%, 5% 10%, 15%, 20%, 25%, 30%. And to check the properties of fresh concrete and hardened concrete such as compacting factor, slump and compressive strength, tensile strength, flexural strength respectively. Also concrete plays an important role in long life period of structure so it is also important to check effect on durability by using sulphate attack, chloride ion penetration, drying shrinkage.

Problem of coal ash disposal

It is becoming very major problem of generated coal ash disposal presently, out of 110 million tons of total ash generated, about (55%) is being utilized and remaining 45% remains dumped. Therefore it is very important to do utilization of coal ash. Presently majority of the coal ash generated is being handled in wet form and disposed of in ash ponds which are harmful for the environment and moreover ash remains unutilized for gainful applications. Nearly, 73% of India's total installed power generation capacity is thermal of which coal based generation are nearly 90% (by diesel, wind, gas and steam adding about 10%). Indian coal gives 35% to 45% ash which is responsible for large volumes of pond ash. Thermal Power Plants using coal is chief source of energy in our country and it is likely to remain so in near future Construction of large ash disposal areas results in resettlement issues and loss of agricultural production, grazing land and habitat as well as other hand use impacts from diversion of large areas of land to waste disposal [10-16].

The total production of fly ash per annum has already crossed 100 million tones and the disposal of the fly ash is causing several challenges. Utilization of fly ash has picked up but till the percentage utilization is far below satisfaction and power plants are no option but to dispose the fly ash in ash pond. Presently Bhusawal Thermal Power Station (M.S.) has 1500 MW capacity of thermal power station and BTPS alone, nearly 1000 MT. of pond ash is produced every day. Effective utilization of pond ash is very essential to reduce the environmental problems caused by the accumulation of pond ash. If it is found suitable for construction industry, large scale utilization of pond ash would be possible and this will become a major contribution factor for reducing pollution. Future more a precious Natural resource as sand is becoming scare and quarrying of sand has been restricted in many places near BTPS. This has lead to look for possibility of partial replacement of sand by pond ash without compromising on strength [8]. The coal fly ashes contain toxic metals in much higher concentrations that are released into the environment by thermal power plants based on coal combustion. Disposal of coal fly ash in open and unlined ash ponds causes serious adverse environmental impacts due to its elevated metals concentrations and its leaching into soils and groundwater [7].

The fly ash gets mixed with bottom ash and disposed off in large pond or dykes as slurry. It is also termed as ponded fly ash and contains relatively coarse particles. The large areas of land are used to store such a mixture of pond ash resulting in land degradation near the thermal power plants. As the pond ash is being produced at an alarming rate, hence the efforts are required to safely dispose it and if possible find ways of utilizing it [11,12]. In the pond ash the dissolvable alkalies present are washed with water. The metal oxides, sulphur, siliceous & aluminous materials with less pozzolonic properties than fly ash, are some main constituents of pond ash. These ash produced, if disposed of unscientifically, can cause environmental risks i.e., air pollution, surface water and groundwater pollution and thus its safe disposal is indispensable. In fact, the pond ash is a mixture of fly ash and bottom ash. The main difference between pond ash and fly ash is in their particle size. The pond ash being coarser and less pozzolonic and hence is not being accepted as pozzolona [13]. Though fly ash is known to be an inert material; there is an appearansion about certain soluble chemicals in the decanted water which can have adverse effect if such decanted water is let into a river body or ground water. For this purpose, the norms of Pollution Control Board insist on providing a plastic liner over the entire bottom of the pond and upstream face of the ash dyke. New ash ponds being constructed have to provide the plastic liner to prevent pollution of ground water [14,15]. Due to the presence of plastic liner, provision of the drainage becomes difficult and as result the deposited sediments could not get consolidated to the same extent as that anticipated in the pond without plastic liner. For this reason, whenever plastic liner is provided, it is important to check the adequacy of strength parameters for the deposited ash for supporting the next section of the dyke if upstream method of construction is adopted.

Apart from pollution to ground water, another major concern is dust pollution in the surrounding area during heavy wind. To prevent dust pollution, water sprinklers shall be arranged in the beach area which is in dry condition. The dust pollution is more from the pond which is not in operation and where construction is in progress by excavating the fly ash. For the pond which has reached the ultimate height and no further extension of height is warranted, the surface shall be covered with a 300mm thick soil layer. Suitable vegetation shall be grown over the area which ensures no dust pollution.

Tests on concrete specimen

In this chapter the description of experimental tests investigation carried out on M25 grade concrete to determine its fresh state properties, hardened state properties and durability of concrete when natural sand [16] is replaced by pond ash are presented. The following tests were conducted to assess the various properties.

Fresh property test on concrete:

- Slump cone test.

Hardened concrete tests:

- Compressive strength test.
- Split tensile strength test.
- Flexural strength test.

Durability tests:

- Weight loss due to sulphate attack.
- Weight loss due to acid attack.
- Loss of Compressive Strength due to immersion in $MgSO_4$ solution.
- Loss of Compressive Strength due to immersion in HCl solution.

Results and Discussion

This chapter gives the interpretation of various test results as below, also present the short discussion on respective results as stated.

Slump cone test

The higher the slump flow (SF) value, the greater its ability to fill formwork. Test results are tabulated as below in Table 1.

Discussion on test results: As percentage of pond ash is increased the workability is reducing. Main reason for this is the water absorption of pond ash.

Compression strength test

Compressive strength of concrete mixes made with various percentage of partial replacement of sand by pond ash was determined at curing period of 3rd, 7th, 28th and 56th days. The results are as follows in Table 2.

Discussion on test results: Experimental results proves that, as percentage of pond ash increases in concrete it leads to the increase in compressive strength of concrete only up to partial replacement of 20% of natural sand by pond ash and beyond that percentage of pond ash there is reduction in strength of concrete. Also the pond ash concrete gains strength

at slower rate in the initial period and acquires strength at faster rate beyond 28 days, due to pozzolonic action of pond ash. The graphical representation of results is shown in respective Figures 1-6.

Split tensile strength test

The results of split tensile strength for various replacements of partial replacement of natural sand by pond ash are as follows in Table 3.

Average Split tensile Strength Discussion on test results- It is observed from results that the splitting tensile strength of concrete increases only up to partial replacement of 20% of natural sand by pond ash, beyond that it decreases with the increase in the percentage of fine aggregates replacement with the pond ash.

Flexural strength test

The results of flexural strength for various replacements of partial replacement of natural sand by pond ash are as follows in Table 4.

Average Flexural Strength Discussion on test results- It is observed from results that the splitting tensile strength of concrete increases only up to partial replacement of 20% of natural sand by pond ash, beyond that it decreases with the increase in the percentage of fine aggregates replacement with the pond ash.

Table 1. Slump flow value.

S. No.	% Pond ash	Slump (mm)
01	0	113
02	5	105
03	10	100
04	15	96
05	20	90
06	25	80
07	30	75

Table 2. Average compressive strength.

S. No	Replacement of Pond Ash	Average Compressive Strength			
		3 days	7 days	28 days	56 days
		N/mm²	N/mm²	N/mm²	N/mm²
1	0%	13.36	17.15	26.78	28.59
2	5%	9.66	17.07	27.05	29.13
3	10%	9.07	16.74	27.44	30.28
4	15%	8.68	16.36	27.94	30.71
5	20%	8.00	16.06	28.24	31.20
6	25%	7.41	15.20	24.95	27.20
7	30%	6.81	14.99	23.17	25.57

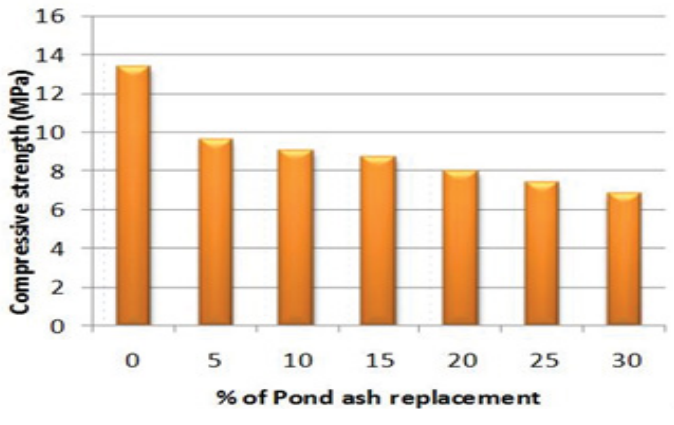

Figure 1. 3 days compressive strength of concrete with varying % of pond ash.

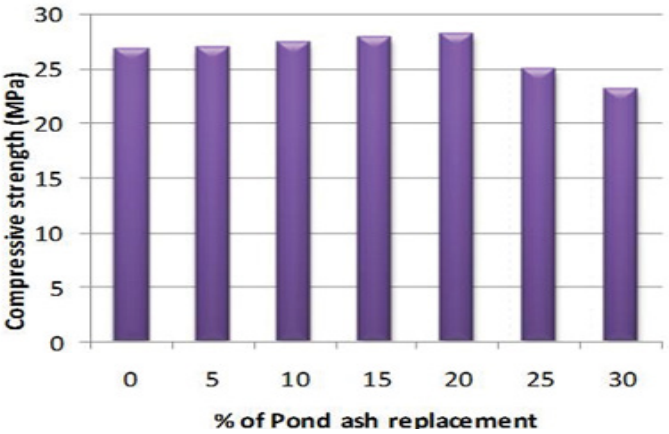

Figure 2. 7 days compressive strength of concrete with varying % of pond ash varying % of pond ash.

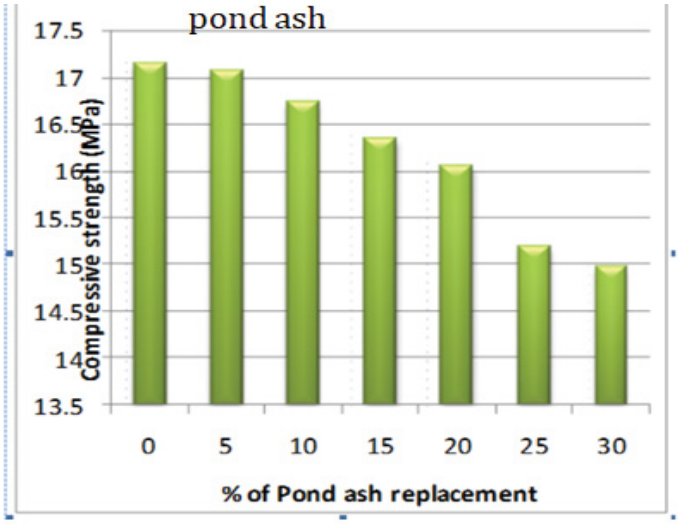

Figure 3. 28 days compressive strength of concrete with varying % of pond ash.

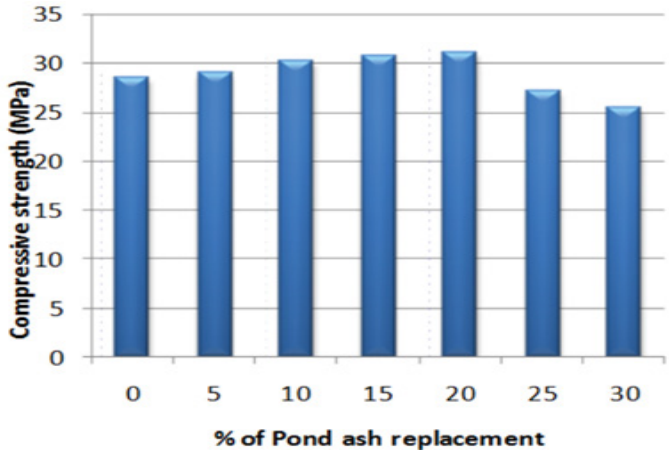

Figure 4. 56 days compressive strength of concrete with pond ash.

Resistance to sulphate attack on concrete

Average % weight loss and compressive strength results are listed in adjacent Table 5.

Discussion on test results- Experimental results show that there is no effect of sulfate solution on concrete when partial replacement of natural sand by pond ash is used in concrete. The solution is not effect on the compressive strength of concrete also. That mean when natural sand is replaced by pond ash then there is no any adverse effect on durability of concrete.

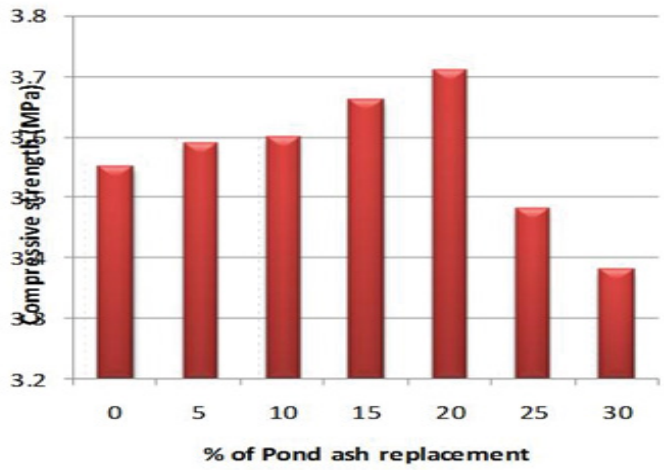

Figure 5. 28 days split tensile strength of concrete with varying % of pond ash.

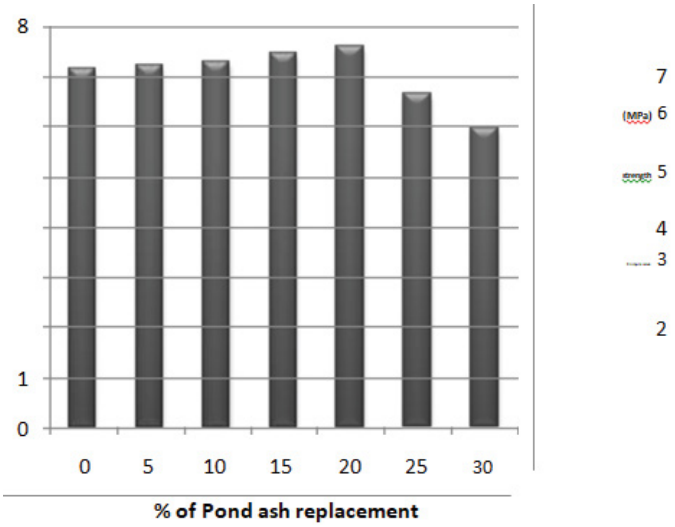

Figure 6. 28 days flexural strength of concrete with varying % of pond ash.

Table 3. Average split tensile strength discussion on test result.

S. No	Replacement of Pond Ash	Average Split tensile Strength (N/mm²)
1	0%	3.55
2	5%	3.59
3	10%	3.60
4	15%	3.66
5	20%	3.71
6	25%	3.48
7	30%	3.38

Table 4. Average flexural strength discussion on test results.

S. No	Replacement of Pond Ash	Average Flexural Strength
1	0%	7.14
2	5%	7.23
3	10%	7.28
4	15%	7.46
5	20%	7.6
6	25%	6.64
7	30%	5.94

Conclusion

The conclusions based on experiments conducted and observations from the present study are listed below

Table 5. Weight loss and compressive strength variation due to sulphate attack on concrete after 28 days.

Pond ash %	Initial wt.	Final wt.	% wt. loss	Compressive strength (Mpa)
0 days	7.882	7.896		27.11
	7.736	7.748		27.47
	7.96	7.975		26.84
Average	**7.859**	**7.873**	**-0.18%**	**27.14**
5	7.746	7.76		27.2
	7.816	7.831		27.56
	7.534	7.55		27.91
Average	**7.698**	**7.713**	**-0.19**	**27.56**
10	7.404	7.426		28
	7.882	7.902		27.91
	7.754	7.776		28.18
Average	**7.68**	**7.701**	**-0.27%**	**28.03**
15	7.444	7.464		28.36
	7.806	7.828		28.09
	7.606	7.63		27.91
Average	**7.618**	**7.64**	**-0.29%**	**28.12**
20	7.882	7.908		28.53
	7.736	7.76		28.89
	7.642	7.668		28.09
Average	**7.753**	**7.778**	**-0.32%**	**28.5**
25	7.49	7.499		25.33
	7.653	7.665		24.98
	7.872	7.882		24.8
Average	**7.671**	**7.682**	**-0.14%**	**25.04**
30	7.288	7.292		23.38
	7.564	7.568		23.2
	7.414	7.42		23.02
Average	**7.422**	**7.426**	**-0.05%**	**23.2**

1. Indian Standard method is easy method for the mix design of M25 grade concrete.
2. Pond ash shows the more water absorption as compared to natural sand.
3. As percentage of pond ash is increased the workability is reducing.
4. 20% of pond ash as sand replacement is found to be the optimum amount in order to get a favorable strength.
5. The pond ash concrete gains strength at slower rate in the initial period and acquires strength at faster rate beyond 28 days, due to pozzolonic action of pond ash.
6. Strength of pond ash concrete decreases with increase in percentage of replacement of sand by pond ash.
7. The compressive strength of concrete with pond ash increases with increased curing period.
8. It is observed from results that the splitting tensile strength of concrete increases only up to partial replacement of 20% of natural sand by pond ash, beyond that it decreases with the increase in the percentage of fine aggregates replacement with the pond ash.
9. It is observed from results that the splitting tensile strength of concrete increases only up to partial replacement of 20% of natural sand by pond ash, beyond that it decreases with the increase in the percentage of fine aggregates replacement with the pond ash.
10. There is no any adverse effect of sulfate solution on concrete when

partial replacement of natural sand by pond ash is used in concrete.

11. The sulfate solution is not effect on the compressive strength of concrete also. That mean when natural sand is replaced by pond ash then there is no any adverse effect on durability of concrete.
12. There is no any adverse effect of chloride solution on concrete when partial replacement of natural sand by pond ash is used in concrete.
13. The chloride solution is not effect on the compressive strength of concrete also. That mean when natural sand is replaced by pond ash then there is no any adverse effect on durability of concrete..

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