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Effective Utilisation of Pond Ash Waste by Replacing Conventional Fine Aggregate in Concrete with Pond Ash

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ABSTRACT: Several attempts have been made to replace the natural sand by various materials. The new trend in this area is Pond Ash. In the subsequent topics we shall discuss about Pond Ash. In order to examine the usability of coal ash as an aggregate for concrete, the mechanical properties and durability of concrete using pond-ash was analyzed in terms of pond-ash content (10, 20, 30 wt.%) as a part of fine aggregate. Since the excess consumption of natural sand has led to scarcity of natural aggregates required for various construction activities, it has become very important to find out effective alternative aggregates to carry out the construction activities. An attempt has been made in this project to check the feasibility of use of Pond Ash as fine aggregates in concrete. This work is an attempt to replace sand by a waste product 'Pond Ash', which is available in the vicinity.

KEYWORDS: Pond Ash, Concrete, Natural Sand.

I. INTRODUCTION

The progress and development in the infrastructural facilities is generally considered as a symbol of the social and economic development of that country. The advancement in the construction sectors like roadways, waterways, railways, skyscrapers and other civil engineering services help a nation grow in all aspects. All the developed nations of the world have therefore stressed a bit more on providing basic infrastructures to their society and hence their construction industry is more advanced and developed compared to construction industry of other nations.

India being a developing nation has to create much more facilities and services in the construction sector. The construction industry in India therefore has a wide scope for progress and development. Construction industry in India is developing rapidly. With this development more and more natural resources are being used for the various construction activities. This development ultimately affects the environment. Hence it is time to try some new materials to avoid adverse effects of using natural materials like sand in concrete. This work is an attempt to replace sand by a waste product 'Pond Ash', which is available in the vicinity.

II. RELATED WORK

R. Kumar et. al. carried out a research on engineering behavior of fiber reinforced pond ash in the year 1999. Their research presents the results of laboratory investigations conducted on salty sand and pond ash specimens reinforced with randomly distributed polyester fibers. The test results reveal that the inclusion of fibers in soils increases the peak compressive strength, CBR value, peak friction angle, and ductility of the specimens. It is concluded that the optimum fiber content for both silty sand and pond ash is approximately 0.3 to 0.4% of the dry unit weight **[1].** An investigation on the use of pond ash for manufacturing bricks in 2002 was carried out by Piyush Kant Pandey & Raj Kumar Agrawal. This ash is generally disposed off in the ash ponds along with other sludges and residues of steel making operations. This changes the constitution of Fly ash and makes the brick manufacturing difficult. This paper has attempted to decide the ways for the use of this mixed ash for manufacturing mixed ash clay bricks successfully. The

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bricks thus made are superior in structural and aesthetic qualities and portents huge saving in the manufacturing costs with better consumer response **[2].** Lee Bong Chun et.. al from Korea studied the fundamental properties of concrete containing pond ash in the year 2008. In this study, sample specimen for five domestic disposal sites could be procured by implementing geological surveys, and the analysis on their grading distribution, chloride contents and the properties of pond ash was conducted. During the test, ordinary Portland cement has been used. Fine aggregates and coarse aggregates used in this test are the products manufactured in the regions as Incheon and Namyangjoo, both of which are accordant with the Korean Standards. The research concluded that pond ash should be utilized by identifying its quality which differs along with disposal site. The study also showed that an increase in the content of pond ash might give higher strength by altering the water cement ratio **[3].** Mrs.R.S.Bang et.. al carried an experimental study on pond ash as fine aggregates in concrete in 2009.They made different proportions of concrete mix for different proportions of replacement of sand by pond ash. Five different mixes were prepared for this purpose. It was concluded that density of concrete decreases with increase in pond ash. They also found that compressive strength of concrete with pond ash increases with more curing period **[4].** A.Sofi et. al. investigated the utilization of pond ash for pavement blocks in 2009.In this work sand was replaced by pond ash in pavement blocks in different percentages like 20%,40%,60%,80% and 100%respectively.The results obtained for 100% replacement were found satisfactory. Strength for M20 was found as 46.18 MPa and for M30 concrete the strength was found to be 36.018 MPa **[5].** Ritwik Sarkar et. al. studied the addition of pond ash on the properties of ash clay burnt bricks in 2009. Two types of ashes were used, pond ash and ESP (Electro-Static Precipitator) grade fly ash (both from Titagarh thermal power plant, West Bengal, India) and local clay (from Durgapur, West Bengal, India). The thermal power plant uses coal from various sources in Bihar, India. Different ratios of clay and ash were used for making the bricks, which were formed in a hydraulic press. The pressed bricks were dried, fired and characterized for the conventional properties of building bricks. They concluded that Pond ash with high proportion of coarse particles may be incorporated at up to 40% without reducing the quality of bricks. **[6].**

III. METHODOLOGY

The problem of collection and disposal of the industrial process residues such as the pond ash and sludges from the various industrial operations has become one of the most hazardous environmental problems for the entire world. Pond ash is considered a hazardous waste due to the probable leaching of potentially toxic substance into the surface water, ground water and soil. Hence, there is a need to effectively use pond ash. Pond ash is examined for its suitability in applications such as ash alloys, ceramic tiles, fire bricks, insulation products, mineral wool, ceramic fibre, distemper, synthetic wood, fire abatement applications, soil conditioner, mine filling, roads and embankment, cement etc. Utilization of pond ash can result not only in reducing the magnitude of the environmental problems, but also to exploit pond ash as a raw material for value added products, and for extraction of valuable materials. Amongst many uses of pond ash, its use as building material is particularly suitable because it is predicted that there would be considerable shortfall in production of various building materials. The use of pond ash in the manufacture of building bricks is well known and is important for bulk volume utilization. Recently, researches on the possible utilization of pond ash as fine aggregates for concrete on the construction materials or the building structures have been implemented, yet the results are not satisfactory as the shape of pond ash differs according to the places of origin of the coal used and the performance of generating facilities, and the properties of it greatly varies according to the field of utilization. From the reason above, a basic research on the utilization of bottom ash as fine aggregates for concrete has been implemented.
For the present study, concrete of M20 grade is designed using IS method. Cubes of the above grade are tested at the age of 7, 14, and 28 days. The designed mix is designated as M1 for different % of Pond ash (replacement of Fine aggregates). Various mixes are prepared such as M1, M2, M3, M4, and M5.

Aims of Mix Design: The object of mix-design is to determine the most appropriate proportions of the constituent materials to meet the needs of construction work. The concrete thus obtained should fulfill the following requirements:-

1. Comply with the specification requirement for structural strength which is usually stated in terms of compressive strength of standard test specimens.
2. Have satisfactory durability in the environment in which the structure is placed.
3. Have a satisfactory appearance in those situations where it is exposed to view.
4. Be capable of being mixed, transported, placed & compacted efficiently and be as economical as possible.

Hence mix-design is an art of choosing the economic proportions of cement, fine aggregates, coarse aggregates and water & admixture, if any, so as to obtain a concrete of specified strength and workability & durability from the available materials.

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The Mix design is carried out by performing following steps.
STEP 1: Target Strength for Mix Design:
The target average mean compressive strength at 28 days is given by
Ft = fck + (t) (s)
Where, ft = target mean strength fck = characteristic compressive strength at 28 days is equal to 20 N/mm2 .
s = standard deviation for M20 grade and good degree control is equal to 4.6 N/mm2 .
t = A statistical value depending upon expected proportions of low results (risk factors).
According to IS 456-2000 risk is 5% and risk factor is 1.65
ft = fck +t.s = 20 + 1.65×4.6 ft = 27.8 MPa
STEP 2: Selection of Water cement ratio: a) Strength requirement [cement grade, 53 grade] For M20 grade, w/c = 0.48
STEP 3: Estimation of Entrapped Air:-

Table No: 1

Nominal maximum size of aggregates (mm)	Entrapped Air, as percentage of volume of concrete
10	3
20	2
40	1

For maximum size of aggregates 20mm, entrapped air, as percentage of volume of concrete is 2.0%.
Corrections: As water ratio adopted is 0.3 i.e. lesser than 0.35, hence there is correction to sand to total aggregate ratio , as -1% & as zone II sand is to be used , correction to sand to total aggregate ratio is as , 0% = 24%
There is no correction for water content in spite of change in above condition.
STEP 5: Calculation of cement content.
a) Strength Requirement
b) Cement by mass = water content (kg/m3 of cement) ÷ w/c ratio = 191.6 ÷ 0.48 = 399.16 ≈ 400 kg /m3
c) Absolute volume = 35 – 3.5 = 31.5 % d) Required water content = 186 + 186 ×(3/100) = 191.6 kg/m3
STEP 6: Calculation of aggregate content can be determined from following equations
V = absolute volume of fresh concrete (Gross volume – volume of entrapped air) = 100 % – 2 % = 98 %
V= 0.98 W = mass of required water content per m3 of concrete = 191.6 kg /m3 C = mass of cement (kg) per m3 of concrete = 399.16 kg/m3 Sc= Specific gravity of concrete = 3.15 (standard) P = Ratio of Fine aggregate to total aggregate by absolute volume = 34.5 % = 0.345
Hence the mix proportion is; 1 : 1.314 : 2.92534

IV. EXPERIMENTAL RESULTS

DESIGNATIONS: The concrete obtained by replacing natural sand with pond ash was tested for compressive strength. To carry out the compressive test in view of examining the influence of pond ash as fine aggregate for concrete, five (5) different mixes were prepared. Each different mix is designated by keeping in mind the percentage of sand replacement with pond ash by weight. The designations for each mix are given as below;
M1:- 0% replacement of sand. It is also called control mix with a proportion of 1 : 1.314 : 2.92534
M2:- 25% replacement of sand with pond ash by weight.
M3:- 50% replacement of sand with pond ash by weight.
M4:- 75% replacement of sand with pond ash by weight.
M5:- 100% replacement of sand with pond ash by weight.

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DETAILS OF MIX PROPORTIONS

Table No: 2

Sr. No	Specimen	Cement (kg/m³)	Fine Aggregate (kg/m³)	Coarse Aggregate (kg/m³)	Pond ash (kg/m³)	Water (liter)
1	M1	1.428	2.85	5.71	0	0.6
2	M2	1.428	2.1375	5.71	0.7125	0.6
3	M3	1.428	1.425	5.71	1.425	0.6
4	M4	1.428	0.7125	5.71	2.1375	0.6
5	M5	1.428	0	5.71	2.85	0.6

CASTING OF SPECIMEN: The concrete mixtures prepared were placed in steel cube moulds of 150 mm side. After placing the concrete in moulds it was vibrated using a surface vibrator. Further they were named as M1, M2, M3, M4, and M5 as per the amount of sand replaced by pond ash.
CURING OF SPECIMEN: The cubes obtained after demolding were placed in water tank for curing. They were taken out when required for carrying out compressive tests at 7, 14 and 28 days
TESTING OF SPECIMEN: In total 45 cubes of side 150 mm were fabricated. Nine (9) cubes of five mixes were prepared for the work. All the cubes were tested for finding out the compressive strength of the five different mixes and the results were recorded in MPa. All the compression tests were conducted on Compression Testing Machine (CTM). The capacity of the CTM is 40 tones.
RESULTS: The results of the compressive tests conducted for the five different mixes were obtained for the age of 7, 14 and 28 days. The compression strength of each mix is tabulated. These results are plotted on Graph of Compressive strength in MPa against Age in days.

Table No: 3

Sr. No.	Mix	Age In days	Compressive Strength (MPa)	Replacement of Fine Aggregates
1	M1	7	19.85	0 %
		14	23.11	
		28	32.78	
2	M2	7	17.56	25 %
		14	23.17	
		28	32.33	
3	M3	7	17.33	50 %
		14	18.66	
		28	25.33	
4	M4	7	16.89	75%
		14	17.62	
		28	23.11	
5	M5	7	16.29	100 %
		14	17.48	
		28	20.14	

The compression strength test for nine (9) cubes of five mixes each designated as M1, M2, M3, M4, and M5. The experimental results for the mixes M1, M2, M3, M4, and M5 are tabulated in observation in above table The compressive strength results are graphically represented from Graph.The 28 days average compressive strength of the control mix M1 for 0% replacement is 32.78 MPa.The same strength for M2 is almost equal to that of M1 for 25% replacement of sand by Pond ash. The strength of M3 for 50 % replacement by Pond ash is 25.33 Mpa.The results show that the compression strength decreases when 50% of natural sand is replaced with Pond ash.

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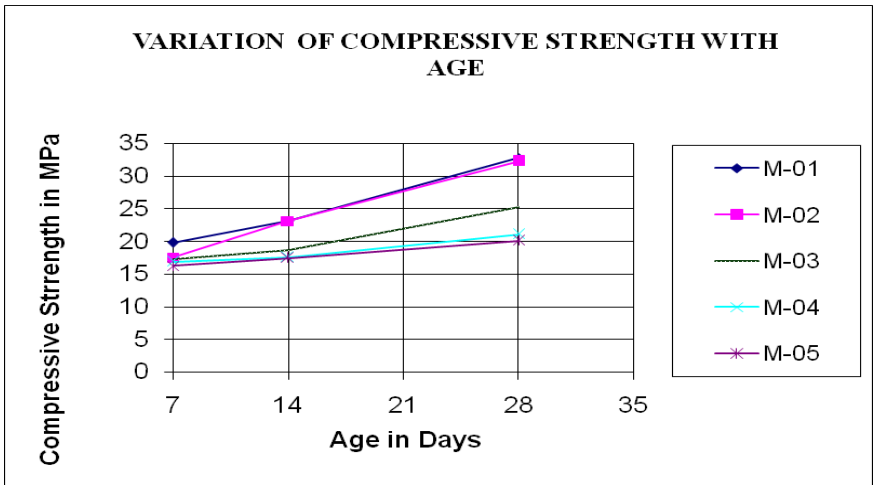

The 28 days strength for M4 having 75 % of Pond ash further decreased which is 23.11MPa and that for M5 having 100 % Pond ash was minimum i.e. 20.14 MPa.In general, the compressive strength of concrete decreases with the increase in Pond ash contents.

V. CONCLUSION

From the results of the study to utilize Pond Ash as fine aggregate for concrete; the following conclusions can be drawn;

1. The average compressive strength of Control Mix M1 at 28 days is 32.78 MPa
2. The average compressive strength of Concrete gradually decreases when the percentage of Pond ash increases.
3. The average compressive strength of Concrete Mix M2 having 25 % of sand with Pond Ash by weight of sand was almost equal to the compressive strength of Mix M1 which was 32.33 MPa.
4. Further the average compressive strength of Mixes M2, M3, M4 and M5 decreases as the percentage of Pond Ash increases and is minimum for Mix M5 with 100 % replacement of sand with Pond ash whose compressive strength is minimum i.e. 20.14 MPa.
5. The basic aim of this project is to save the excess consumption of natural sand and find an alternative for the same. The use of concrete containing Pond ash should be promoted in applications where good strength of concrete is not preferred.
6. With the use of Pond Ash concrete, though not entirely, but at least to some extent the consumption of natural sand can be reduced. This project work can be considered as an initial step towards the same.

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