Effect of pond ash as sand replacement on properties of concrete

Sanket Sunil Bhadane, student MBA project and construction management, MITCOM MIT-ADT University Pune India, sanket7bhadane@gmail.com

Akhilesh Jitendra Jagtap, student MBA project and construction management, MITCOM MIT-ADT University Pune India, akhileshjagtapofficial@gmail

Abstract: Pond ash has coarser particle size which is comparable with particle size of sand. Hence, the beneficial use of pond ash in concrete is the preferable option for safe and economical utilization of millions of tons of pond ash. In India it is observed that at very few places good quality of sand may be available in plenty. All metro and mega cities in India are facing acute shortages of good quality of sand. In contrast to the sand, pond ash is available in huge quantity that too at free of cost from thermal power plants in India. An attempt is made, to use pond ash as sand replacement in concrete.

In this study pond ash, which is obtained from Eklahare thermal power plant, near Nashik city in Maharashtra is used. Mix design M-40 grade of concrete was prepared with fixed w/c ratio 0.40 and slump was kept 100 ± 10 mm throughout the study. In this study natural river sand was replaced with pond ash by 0%, 10%, 20%, 30%, 40%, 50 % by volume. Compressive strength, split tensile strength, flexural strength was determined at 7, 28 & 56 days the result shows that the compressive strength, split tensile strength and flexural strength decreased as compared to controlled concrete as the percentage of replacement of pond ash increased. It was observed that up to 20% replacement the results of compressive, flexural, split tensile strength are slightly higher compared to that of the controlled concrete and remaining replacement strength was found less as compared to control concrete.

Keywords — compressive strength, concrete, flexural strength, pond ash, sand, split tensile strength

I. INTRODUCTION

Cement concrete is one of the seemingly simple but complex and most widely used construction material in the world today. Many of its complex behavior are yet to be identified to employ this material beneficially and economically. It is difficult to point out another material of construction which is as versatile as concrete. Today cement concrete is most widely used engineering construction material due to its excellent resistance to water and hence protects reinforcement from corrosion, plastic consistency which enables it to flow into variety of shapes and sizes as per requirement, it is relatively economical in the long run as compared to other engineering material. In many countries, the construction industry is rapidly growing, which involves the use of natural resources such as sand, to develop the infrastructure. This growth is affected by the lack of availability of good-quality natural resources. In concrete, cement with water forms a binder phase, whereas the aggregate phase is mainly a filler phase that occupies approximately 70 to 75% of the concrete volume, of which the fine aggregate is approximately 28- 40 %.Aggregates are considered one of the main constituents of concrete since they occupy more than 70 % of the concrete matrix. In many countries there is shortage of natural aggregates that are suitable for construction while in other countries there is an increase in the consumption of aggregates due to the greater demand by the construction industry. In order to reduce dependence on natural aggregates as the main source of aggregate in concrete, artificially manufactured aggregates and artificial aggregates generated from industrial wastes provide an alternative for the construction industry. In concrete construction, the prime source of fine aggregate is naturally available river sand, which is not widely available during floods and rainy seasons and because of the huge demand of the construction industry. In order to solve this problem, a reliable source and continuous supply of an alternative material for these ingredients should be found, and their use is recommended. It is essential that this recommended alternative material is eco-friendly and easily available at a low cost without an interrupted supply. Most construction sites have a procurement problem and an interrupted supply of good-quality river sand throughout the year, particularly in rainy

 DOI : 10.35291/2454-9150.2020.0528

seasons extremely fine sand is carried near estuaries and this sand is useless for concrete construction work.

Natural resources are being depleted worldwide and the amount of generated wastes from industry is considerably increasing. Sustainable development for construction involves using non-conventional materials, such as copper slag and bottom ash, to compensate for the lack of natural resources and to find alternative methods to conserve the environment. Therefore, aggregates from industrial waste can be used as substitute to artificial and natural aggregates. Thermal power plants are the main source of power generation in India. These thermal power plants have been generating approximately two-thirds of the power demand of the country. In thermal power stations, coal is used to generate the required heat and utilization of large quantities of coal produces huge amount of fly ash, bottom ash and pond ash. There are approximately forty major thermal power plants in India. Many reported that the world currently produces approximately 1528 million tons of coal fly ash, whereas India currently produces approximately 120 million tons of coal fly ash from thermal power stations, which produce approximately 30-40 % of coal ash. Large production of bottom ash requires a large space to dump the material. The major obstacle in the use of bottom ash in concrete is that the chemical properties of coal bottom ash differ from place to place and depend on the origin of the raw material.

As review of the recent research showed that, it is possible to utilize industrial by products as well as other waste material in the production of normal concrete and high strength concrete when used as partial or full replacement of cement or aggregate.

Also, it has been demonstrated that most of the concrete manufactured (either normal or HSC) made from wastes and industrial resources have superior properties compared with the conventional concrete in terms of strength, performance and durability.

II. METHODOLOGY

I. Materials

a. Cement

Ultra Tech 53 grades Ordinary Portland cement was used for this study in compliance with BIS:269-1989 R1998. It is the most widely used type of cement in the construction industry in India.

b. Coarse and fine aggregate

Coarse aggregates of 10 and 20 mm size were collected from the Masrul-Nashik region, Maharashtra, India. The natural sand of the river bed produced from the Tapi River, Nandurbar Maharashtra, India, according to the grading Zone 1 and confirming ofBIS:383-1970 R-1997.

c. Pond ash

Pond ash was obtained from the Eklahare Thermal Power Plant, Nashik city, Maharashtra, India.

d. Plasticizer

Emceplast BV Plasticizers were used as directed by the manufacture to improve the workability of the fresh concrete mix according to BIS:2645-2003. As the percentage of pond ash was increased in the mix the workability of concrete was considerably reduced due to the high-water absorption of pond ash. To achieve the required slump i.e. 100 ± 10 mm the plasticizers was used.

e. Water

Potable (drinking) water was used for casting and curing processes of the concrete specimens. After casting, all cubic, cylindrical and beam specimens were kept for curing in the curing tank. While curing the specimens, water was replaced every week.

III. PHYSICAL AND CHEMICAL PROPERTIES

II. Fineness modulus

To determine the fineness modulus of sand, pond ash and coarse aggregates of 10mm&20mm detailed sieve analysis is performed. The fineness modulus of coarse aggregate (10mm and 20mm), sand and pond ash are 7.0, 7.3, 3.5 and 2.06 respectively. Sand used for this work is from grading zone I and pond ash used in this work is from zone II.

III. Specific gravity

The specific gravity of coarse aggregate(20mm &10mm), sand and pond ash is determined by using Pycnometer and are found to be 2.81, 2.68,2.59 & 1.68 respectively. It is observed that the specific gravity of pond ash is less as compared to sand.

IV. Water Absorption

The water absorption of coarse aggregate (10mm &20mm), sand &pond ash are determined by conventional method and are found to be 1.144%, 1.225%, 1.245% & 24.468% respectively. It is found that water absorption of pond ash is very high as compared with the natural sand and it also has effects on workability of concrete Table 1,2,3 shows the physical properties of coarse aggregates, sand and sieved pond ash.

Table 1: Fineness modulus of coarse aggregate, fine aggregate and sand with pond ash.

Fineness modulus			
C.A. (20mm)	C.A. (10mm)	Sand	P.A.
7.3	7.0	3.5	2.06

 DOI : 10.35291/2454-9150.2020.0528

ISSN : 2454-9150 Special Issue - .inSIGHT'20

Table 2: Specific gravity of coarse aggregate, fine aggregate and sand with pond ash

Specific gravity			
C.A. (20mm)	C.A. (10mm)	Sand	P.A.
2.81	2.68	2.59	1.683

Table 3: Water absorption of coarse aggregate, fine aggregate and sand with pond ash

Water Absorption			
C.A. (20mm)	C.A. (10mm)	Sand	P.A.
1.144%	1.225%	1.245%	24.468%

V. LABORATORY TESTING PROGRAM

The mix proportion and mix ratio chosen for this study is shown in Table 2. concrete mixture with different proportions of pond ash ranging from 0 % (for control mix) and 10%, 20%, 30%, 40% & 50% replacement for sand were considered. The M-40 grade mix design was selected for w/c ratio 0.40. For this work total 54 cubes specimen, 54 cylindrical specimens and 54 beam specimens were casted and tested for compressive strength, split tensile strength, flexural strength. For this work total 162 test specimen were casted. Table 3. shows the material consumed with different proportions of pond ash with cement in one kg/ m^3. The mix designs is selected for w/c ratio of 0.40 for controlled concrete and 9 cubes are casted and tested for 7, 28, 56 days. The compressive strength at 7, 28& 56 days is found 31.42N/mm^2, 47.92 N/mm^2 & 58.81 N/mm^2respectively. For the controlled concrete 9 cubes specimen, 9 cylindrical specimens and 9 beam specimens are casted and tested for 7, 28, 56 days

Table 4:Mix Proportions (Kg) and Mix Ratio

Cement (Kg/mm^3)	F.A. (sand) (Kg/mm^3)	C.A. (20 mm)	C.A. (10 mm)	Water
418.625	688.54	438.78	278.98	167.45
1	1.64	1.14	1.71	0.4

Table 5:Concrete mixture with different proportions of Pond Ash

Mix material % Replacement	Cement Kg/m^3	Pond ash Kg/m^3	Water Kg/m^3	Sand Kg/m^3	C.A 20mm Kg/m^3	C.A 10mm Kg/m^3
CC	418.625	-	167.45	688.54	731.31	464.98
10	418.625	44.74	167.45	619.68	731.31	464.98
20	418.625	89.48	167.45	550.83	731.31	464.98
30	418.625	134.22	167.45	481.97	731.31	464.98
40	418.625	178.96	167.45	413.12	731.31	464.98
50	418.625	223.7	167.45	344.27	731.31	464.98

1.III.I.1. Preparation of test specimens

For mixing the concrete a half bag mixture is used. First coarse aggregates of20 mm, 10 mm were placed in the mixture then sand and cement were mixed together in dry state then water is added in addition with BV plasticizer and mixed until the homogeneous mixture were obtained. Each batch is mixed around 3 to 5 minutes and then the mixture is placed in a metallic try and immediately the slump was checked before the concrete was placed in different mould. For this work tap water was used throughout the process and even for curing purpose.

1.III.I.2. Cube

Cube of size 150 mm × 150 mm × 150 mm were used. The cubes were cleaned thoroughly with a waste cloth and then oil was properly applied along its faces. Concrete was then filled in mould in three layers, while filling the mould concrete is compacted using tamping road of 600 mm having a cross sectional area of 25 mm2 then the mould are kept on the vibrating table for 60 seconds to achieve proper compaction and then the mould are kept on plane and level surface in the laboratory for 24 hours and then cubes are removed from the mould and kept for curing. For this report 54 cube specimen are casted and tested.

1.III.I.3. Cylindrical

Cylindrical mould of height 300 mm and diameter 150 mm were used. The oil was properly applied along the inner surface of the mould for easy removal of cylinder from the mould. Concrete was poured throughout its length and compacted well by tamping rod as well as on vibrating table. For this report 54 cylindrical specimen are casted and tested.

1.III.I.4. Beam

Mould of beam of size 100 mm × 100 mm × 500 mm was used. The oil was applied along the inner surface of the mould for easy removal of beam from mould. Concrete was poured throughout its length and compacted well by tamping rod as well as on vibrating table. For this report 54 beam specimen are casted and tested.

1.III.I.5. Curing

After casting of all cubes, cylindrical and beam specimen they are kept for curing in curing tank. The tap water is used for curing purpose. While curing the specimens, after every seven days water is removed and fresh water is added.

VI. RESULT AND DISCUSSION

A. Effect of pond ash on compressive strength

Compressive strength of concrete mix made with and without pond ash of cubes size 150 mm × 150 mm × 150 mm was determined at 7, 28 and 56 days. The test results are given in Table 4. The maximum load at failure reading was taken and the average compressive strength is calculated using the following relation.

$$\text{Compressive strength } (\text{N/mm}^2) = \frac{\text{Ultimate load in N}}{\text{Area of cross section } (\text{mm}^2)}$$

 DOI : 10.35291/2454-9150.2020.0528

For controlled concrete the compressive strength was found to be 26.42, 42.91, & 53.81N/mm2 for 7, 28 & 56 days respectively. It was observed that for 10%and 20% sand replacement the compressive strength was increased and for 30%, 40%, 50% sand replacement is was decreased, when compared with control concrete.

Table 6: Compressive Strength of pond ash concrete with age

Mix	7 Days in N/mm^2	28 Days in N/mm^2	56 Days in N/mm^2
CC	31.42	47.91	58.81
10PA + 90 S	32.52	48.22	58.98
20PA + 80 S	33.10	49.67	59.22
30PA + 70 S	24.88	43.94	45.83
40PA + 60 S	22.81	43.56	44.05
50PA + 50 S	22.68	42.94	43.33

B. Effect of pond ash on split tensile strength

The specimen of size 150 mm in diameter and length of 300 mm is casted and tested under the digital CTM of capacity 300 ton. The specimen is kept under CTM at the centre with ply wood at top and bottom, and load was applied with rate 0.6 KN/seconds and ultimate loading was noted. Split tensile strength was shown in Table 5. The spilt tensile strength was calculated according to IS - 5816-1970 and IS 516 – 1959 code by the $\sigma_{bt} = \frac{2P}{\pi DL}$ where σ_{bt} =split tensile strength is in N/mm2, L = span, D = Diameter of specimen, P = Maximum load at failure. The split tensile strength for controlled concrete was found 2.23N/mm2, 3.28N/mm2&4.04N/mm2 for 7, 28, & 56 days respectively. It was observed that for 10% and 20% sand replacement with pond ash the split tensile strength was increased and for 30%, 40%, 50% sand replacement is was decreased, when compared with control concrete.

Table 7: Split Tensile strength of pond ash concrete with age

Mix	7 Days in N/mm^2	28 Days in N/mm^2	56 Days in N/mm^2
CC	2.23	3.28	4.04
10PA + 90 S	2.29	3.36	4.46
20PA + 80 S	2.45	3.71	4.51
30PA + 70 S	1.78	2.48	3.21
40PA + 60 S	1.71	2.11	2.45
50PA + 50 S	1.38	2.03	2.50

C. Effect of pond ash on flexural strength

The beam specimen of size 100 mm × 100 mm × 500 mm was tested for single point load at the midpoint under the UTM of capacity 100 ton. The flexural strength is calculated as per IS 456 – 2000 and IS 516 – 1959 by using the relation $\sigma_b = \frac{PL}{bd^2}$Where σ_b= Modulus of rupture in N/mm2, P = Maximum load, L = span, b = width of specimen, d = depth of specimen. The flexural strength for controlled concrete was found to be 3.74N/mm2, 7.76N/mm2&8.68N/mm2for 7, 28 & 56 days. It was observed that for 10% and 20% sand replacement with pond ash the flexural strength was increased for 30%, 40%, 50% sand replacement is was decreased, when compared with control concrete.

The pond ash concrete gains flexural strength with the age that is comparable but less than that of the controlled concrete. It is believed to be due to the poor interlocking between the aggregates, as pond ash particles are spherical in nature. Table 6. Shows the variation in flexural strength for different percentage of sand replacement with respect to controlled concrete for 7 days.

Table 8: Flexural strength of pond ash concrete with age

Mix	7 Days in N/mm^2	28 Days in N/mm^2	56 Days in N/mm^2
CC	3.74	7.76	8.68
10PA + 90 S	3.95	8.52	9.11
20PA + 80 S	4.02	8.95	9.98
30PA + 70 S	3.67	7.45	8.14
40PA + 60 S	3.61	7.24	7.53
50PA + 50 S	3.38	6.61	6.70

VII. Conclusion From Objective

- It was observed that for 10%and 20% sand replacement the compressive strength was increased when compared with control concrete.
- It was observed that for 10%and 20% sand replacement the split tensile strength was increased when compared with control concrete.
- It was observed that for 10%and 20% sand replacement the flexural strength was increased when compared with control concrete.
- It was noticed that fineness modulus of pond ash is more than sand.
- It was noticed that specific gravity of pond ash is less than sand.
- It was noticed that water absorption capacity of pond ash is more than sand.

VIII. REFERENCES

[1]M. P. Kadam & Y. D. Patil (2015), "Effect of sieved coal pond ash as a sand replacement on the properties of cement concrete", Magazine of Concrete Research, Vol. 67, pp. 227–234.

[2]Vasugi, K.Ramamurthy (2014),"Identification of design parameters influencing manufacture and properties of cold-bonded pond ash aggregate" Materials and Design Vol.54 pp. 264–278.

[3]R.K. Mishra, R.K. Tripathi, Vikas Dubey (2016), "Early age shrinkage pattern of concrete on replacement of fine aggregate with industrial by-product", Journal of Radiation Research and Applied Sciences, Vol.9, pp. 386-391.

[4]Sofi,B.R. Phanikumar(2015),"An experimental investigation on flexural behaviour of fibre-reinforced pond ash-modified concrete",Ain Shams Engineering Journal, Vol.6, pp. 1133–1142.

 DOI : 10.35291/2454-9150.2020.0528