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AN EXPERIMENTAL STUDY ON STRENGTH PERFORMANCE OF CONCRETE(M20) WITH PARTIAL REPLACEMENT OF FINE AGGREGATE WITH POND ASH

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ABSTRACT

Power consumption is increasing day by day for utilization. Power is generated from different power plants such as Thermal power plants, hydraulic power plants, solar power plants and etc…, A major portion of the power is generated from thermal power plants. The main source of power generation in thermal power plants is Coal. When combustion of Coal occurs in the power plant, 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. In this study Pond ash is utilized as a partial substitute of fine aggregate (Natural sand) in concrete. The properties of pond ash were determined and compared to the properties of sand. Pond ash is added in the concrete by replacing 10%, 20% and 30% of fine aggregate to determine the strength properties. The Casting of cubes and cylinders are done to determine the compressive strength and split tensile strength respectively, for 7, 28 and 90 days of curing. Optimum strength has been obtained at 20% replacement of fine aggregate by pond ash in cement concrete.

KEYWORDS: Pond ash,Fine aggregate Concrete mix, Strength properties.

INTRODUCTION

Power consumption is increasing day by day for utilization. Power is generated from different power plants such as Thermal power plants, hydraulic power plants, solar power plants and etc…, A major portion of the power is generated from thermal power plants. The main source of power generation in thermal power plants is Coal. When combustion of Coal occurs in the power plant, 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.

Pond ash is a residue collected from ash pond near thermal power plant. It is a non plastic and light weight material having the specific gravity relatively lower than that of the similar graded conventional earth material. The massive generation of pond ash of thermal power plants has become a major cause of concern for people living in and around thermal power plants. The rate of generation of coal ash in India has reached 130 million tons per annum with about 75,000 acres of precious land under the cover of abandoned ash ponds. Pond ash from coal fired generation units in India will reach 170 million tons per annum by the year 2012 whereas; the current rate of utilization of ash is about 35%. Some research works have been carried out to find the stability of compacted pond ash in Geotechnical construction like embankments, retaining walls, structural fills, etc. However, these structures are to be protected from getting wet in order to preserve the inherent strength of compacted pond ash which is a difficult task in field situations. Also pond ash can be utilized to replace the aggregates in concrete in the construction industry. And also the availability of pond ash is bound to provide an economic alternative to natural soils.

MATERIALS

Concrete is composed of cement and aggregates combined with water. It is the most widely used construction material has several desirable properties like high compressive strength, stiffness and durability under usual environmental factors. The raw materials required for the concrete in the present work are Cement, Fine Aggregate, Coarse Aggregate, Water and Pond Ash.

Cement: The most common cement used in the construction industry is ordinary Portland cement confirming to IS-12269_1987. This is made by heating limestone with small quantities of other materials to 1450^{0}C in a kiln and the process is called calcination. The cement to be used for concrete making should be fresh and should have uniform colour. It should not contain any lumps and should be free from foreign matter.

Fine Aggregates: Aggregates passing through a 4.75mm and retained on 150µ sieve are termed as fine aggregates. The fine aggregate conforming to Zone-II according to IS: 383 were used in the mix design. The fine aggregate used was obtained from a nearby river source.

Coarse Aggregates: Aggregates having a size greater than 4.75mm are termed as coarse aggregates. The coarse aggregate used in this experimental investigation is 20mm and below 20mm size, crushed and angular in shape. The aggregates are free from dust before used in concrete.

Water: Water should be clear, potable fresh water with a pH value (7 to 8) which is free from organic substances, durability and concentration of acids. The term drinkable water is often used to explain the need for clean and not contaminated.

Pond Ash: Pond ash is the by-product obtained when fly ash and bottom ash or both mixed together in any proportion with the large quantity of water to make it in slurry form and deposited in ponds wherein water gets drained away. The Pond ash used in this project was collected from Simhadri (NTPC) near Parwada in Visakhapatnam and laboratory study was carried out for silent physical & engineering properties of Pond ash.

TESTS CONDUCTED ON MATERIALS

Cement: The following tests as per IS 4031:1988 are done to ascertain the physical properties of the cement. The results of the tests are compared to the specified values of IS 4031:1988.The various tests conducted on cement are;

- Fineness of cement.
- Consistency.
- Initial and Final setting time.
- Specific gravity of cement.
- Compressive strength of cement.

Table 1 Properties of Cement

Consistency (%)	32
Initial setting time	134 min
Final setting time	292 min
Fineness (%)	2.50
Specific gravity	3.14
Ultimate compressive strength	
3 days(mpa)	28.6
7 days(mpa)	38.6

28 days(mpa)	58.2

Fine Aggregates: The fine aggregate conforming to Zone-II according to IS 383:1970 were used in the mix design. The fine aggregate used was obtained from a nearby river source. The test results on fine aggregate are shown in the table below. The various tests conducted on fine aggregate are:

- Specific gravity.
- Bulk Density.
- Sieve analysis (fineness modulus).

Table 2 Physical properties of Fine Aggregate

Property	**Value**
Specific Gravity	2.59
Fineness Modulus	2.74
Bulk density Loose Compacted	 1352 Kg/m^3 1476 Kg/m^3

Coarse Aggregates: The material whose particles are of size retained on IS sieve size 4.75mm is termed as coarse aggregate and containing only so much finer material as is permitted for the various types described in IS: 383:1970 is considered as coarse aggregate. The coarse aggregate used in this experimental investigation is 20mm and below 20mm size, crushed and angular in shape. The aggregates are free from dust before used in concrete. The various tests conducted on coarse aggregate are:

- Fineness modulus (sieve analysis).
- Specific gravity.
- Bulk density of coarse aggregate.

Table 3 Physical Properties of Coarse Aggregate

Property	**Value**
Specific Gravity	2.62
Fineness Modulus	8.772
Bulk density Loose Compacted	 1379 Kg/m^3 1492 Kg/m^3

Table 4 Sieve Analysis of Fine Aggregate and Coarse aggregate

Fine Aggregate		**Coarse aggregate**	
Sieve size	**% passing**	**Sieve size**	**% passing**
10 mm	100	80 mm	100
4.75 mm	99.05	40 mm	100
2.36 mm	95.85	20 mm	83.6
1.18 mm	77.95	16 mm	30.4

600 µ	44.85	12.5 mm	7.7
300 µ	7	10 mm	1.1
150 µ	1.05	4.75 mm	0

Pond Ash: Pond ash is collected from NTPC Parawada in Visakhapatnam and laboratory study was carried out for salient characteristics of such Grading, Specific Gravity and compaction. The various tests conducted on Pond Ash are:

- Bulk Density.
- Specific gravity.
- Sieve analysis.

Table 5 Sieve Analysis of Pond ash

Sieve size	**% Passing**
4.75	100
2.36	97.8
1.18	92.1
0.6	84.8
0.425	51.5
0.3	12.9
0.15	2.7

Table 6 Physical Properties of Pond Ash

Property	**Value**
Specific Gravity	2.0
Bulk Density	1262 kg/m^3
Fineness Modulus	2.586

RATIO OF MIX PROPORTION

The following table shows the ratio of concrete mix for the design of M20 grade concrete as per Indian Standard Recommended Method of Concrete Mix Design (IS 10262:2009)

Table 7 Mix proportion of concrete mix

Water (Lts)	193.36	-
Cement(kg/m^3)	371.85	1
Fine Aggregate (kg/m^3)	571.04	1.54
Coarse Aggregate (kg/m^3)	1227.52	3.30
W/C- ratio	0.52	0.52

RESULTS AND DISCUSSIONS

Slump Cone Test:

The variation of slump values for all the mixes is measured. It is observed that the nominal concrete itself gave higher slump value and the value of the slump is decreased with the increase of Pond Ash. The values of the slump are given below in the table.

Table 8 Variation of Slump

Mix Designation	Slump value (mm)
M-1	86
M-2	73
M-3	68
M-4	64

- The M-1 represents the standard concrete mix consisting of cement, coarse aggregate, fine aggregate and water.
- The M-2 represents the concrete mix containing fine aggregate replaced with 10% of Pond Ash.
- The M-3 represents the concrete mix containing fine aggregate replaced with 20% of Pond Ash.
- The M-4 represents the concrete mix containing fine aggregate replaced with 30% of Pond Ash.

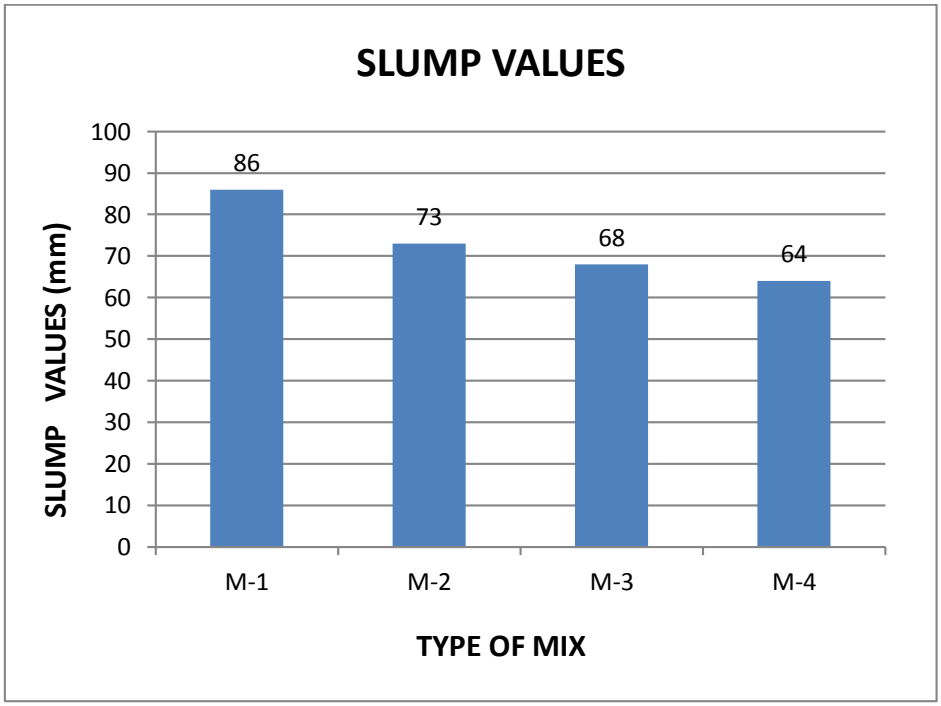

Figure 1 Slump Value V s Type of Mix

Compressive Strength Test:

The specimens are tested by compression testing machine after 7, 28, 90 days curing. The load should be applied gradually at the rate of 140 kg/cm^2.

Table 8 Compressive Strength Test Results

Mix Designation	Compressive strength in N/mm^2 & Variation of Compressive Strength in % with respect to Nominal Mix		
	7 days	28 days	90 days
M-1	22.16 (0)	28.2 (0)	30.7 (0)
M-2	23.92 (+8)	31.16 (+10.5)	34.01 (+11)
M-3	25.47 (+15)	33.28 (+18)	36.84 (+20)
M-4	22.03 (-0.9)	27.92 (-1)	30.39 (-1)

In the above table '+' indicates for increase and '-' indicates for decrease.

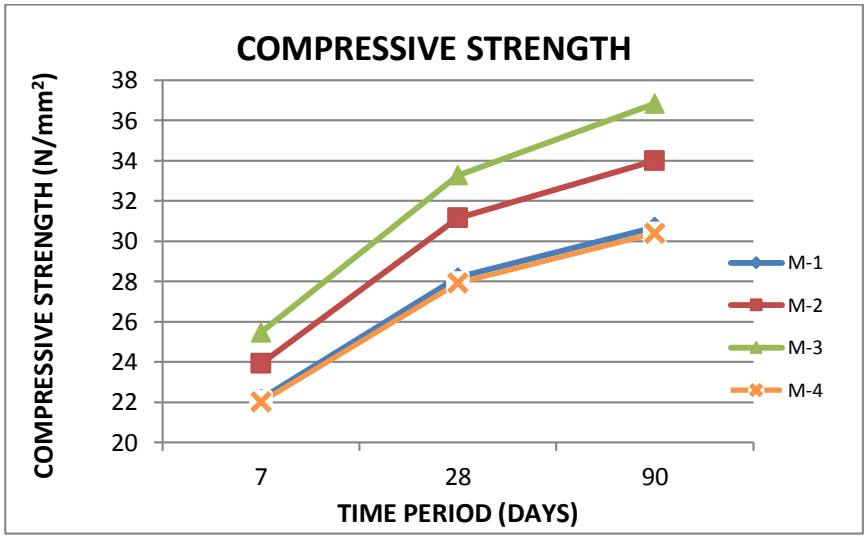

Figure 2 Compressive Strength Vs Time Period

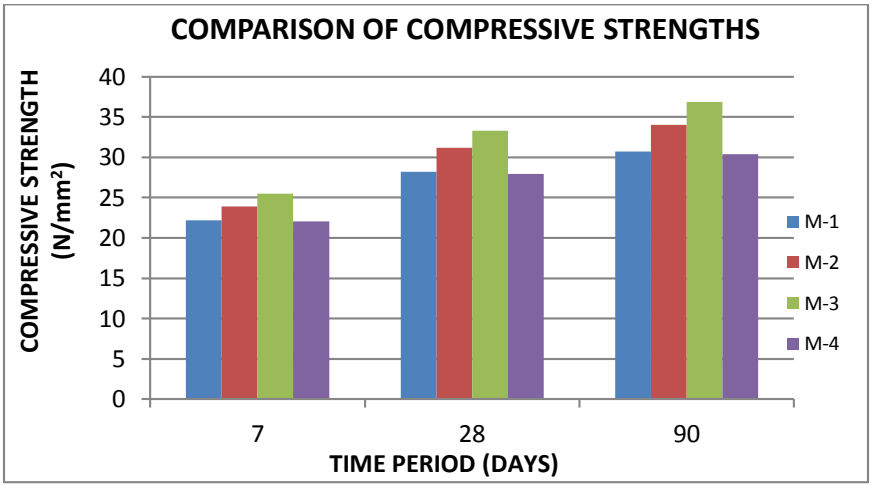

Figure 3 Variation of Compressive Strengths Split Tensile Strength:

The test is carried out by placing a cylindrical specimen horizontally between the loading surfaces of the compression testing machine and the load is applied until the cylinder fails along the vertical axis. Split tensile strength is the product of compressive load on the cylinder, the length of the cylinder and its diameter. Tests are carried out at 7, 28, 90 days.

Table 9 Split Tensile Strength Test Results

Mix Designation	Split Tensile Strength in N/mm^2 & Variation of Split Tensile Strength in Percentage(%) with respect to Nominal Mix		
	7 days	28 days	90 days
M-1	1.2 (0)	2.08 (0)	2.34 (0)
M-2	1.26 (+5)	2.22 (+6.5)	2.5 (+6.8)
M-3	1.39 (+16)	2.43 (+16.6)	2.73 (+17)
M-4	1.17 (-2.6)	2.06 (-1)	2.34 (0)

In the above table '+' indicates for increase and '-' indicates for decrease.

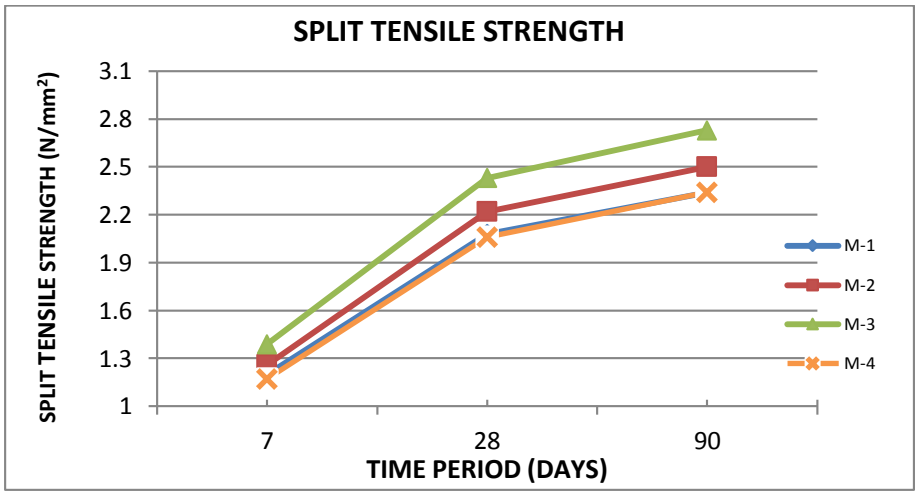

Figure 4 Split Tensile Strength Vs Time Period

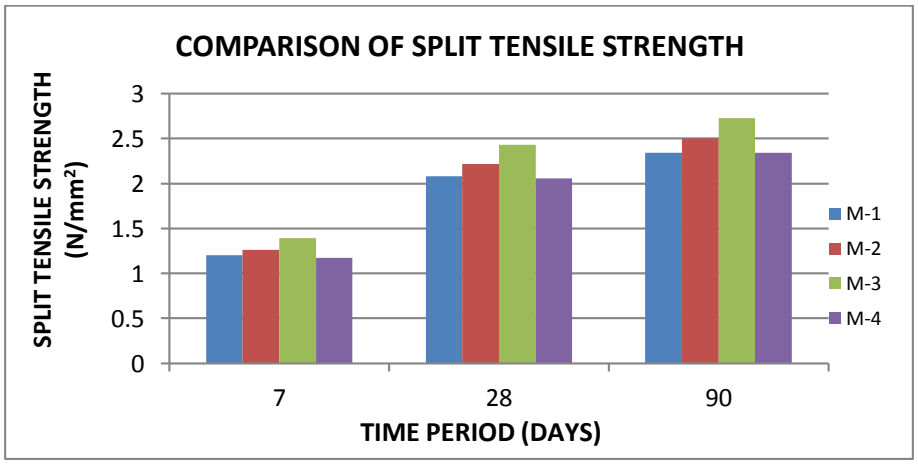

Figure 5 Variation of Split Tensile Strengths

CONCLUSIONS

The following conclusions can be drawn from the results obtained in the laboratory:

1. The tables and graphs drawn for compressive strength of concrete cubes show that the compressive strength increases up to 20% of Pond Ash and reduces beyond that.
2. It is found that the compressive strength of concrete made out of pond Ash is 15%, 18%, 20% more than the conventional concrete at 7, 28, 90 days respectively.
3. The experimental results show that the split tensile strength increases up to 20% Pond Ash beyond which it reduces.
4. It is found that the split tensile strength of concrete made out of quarry dust and marble powder is 16%, 16.6%, 17% more than the conventional concrete at 7, 28, 90 days respectively.
5. The results proved appreciable improvement in compressive strength than that compared with split tensile strengths.
6. The workability of the concrete mix decreased with increased percentage of Pond Ash. The reason is due to higher surface area, which requires more water to wet the surface in comparison with the river sand.
7. In this concrete, waste material is used for the production of concrete which can reduce the problem of disposal of waste and also reduces the cost of production.
8. Therefore, the results of this study provide a strong recommendation for the use of Pond Ash as fine aggregate in concrete manufacturing.

All the experimental data shows that the addition of industrial wastes improves the mechanical properties of concrete. These results are of great importance because of the scarcity of fine aggregate being observed these days. From the above study, it is concluded that the Pond Ash can be used as partial replacement to fine aggregate upto 20%.

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