International Journal of Engineering, Management, Humanities and Social Sciences Paradigms (IJEMHS)
Volume 30, Issue 02, Quarter 02 (April to June 2018)
An Indexed and Referred Journal with Impact Factor: 2.75
ISSN (online): 2347-601x
www.ijemhs.com

A Study on Properties of Concrete by using Fly Ash

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Publishing Date: June 16, 2018

Abstract

Concrete is a material synonymous with strength and longevity has emerged as the dominant construction material for the infrastructure needs for the twenty first century. In addition to being durable, concrete is easily prepared and fabricated from readily available constituents and is therefore widely used in all types of structural systems. The challenge for the civil engineering community in the near future will be to realize projects in harmony with the concept of sustainable development and this involves the use of high performance materials and products manufactured at reasonable cost with the lowest possible environmental impact.

Keywords: *Concrete, Fly Ash, Strength.*

Introduction

Concrete is the most widely used construction material worldwide, however the production of Portland cement, an essential constituent of concrete, releases large amount of CO_2 in to the atmosphere (Since CO_2 is a major contributor to the green house effect and the global warming of the planet). In this scenario, the use of supplementary cementing materials, such as coal ash, slag and silica fume as a replacement for Portland cement in concrete presents one viable solution with multiple benefits for the sustainable development of the concrete industry. The most commonly available supplementary cementing material worldwide is coal ash, a by-product from the combustion of pulverized coal in thermal power plants. Coal ash consists of two parts, fly ash and bottom ash. Fly ash is a finely divided, amorphous alumino silicate that reacts at normal temperature with calcium hydroxide to produce calcium silicate hydrate (C-S-H) with compendious properties i.e. it is pozzolanic material. Bottom ash is a coarser material, which falls into the furnace bottom in large thermal power plants and constitute about 20% of the total ash content.

Research

In the present investigation ordinary Portland cement 43 grade with brand name 'Jaypee Cement' conforming to IS: 8112-1989 was used. The cement was tested in accordance with the test methods specified in IS: 4031-1988 and results obtained are shown.

Plate No. 1: Typical View of Cement

Table 1: Cement Test Results

S. No.	Characters	Experimental Value	As per IS:8112 1989
1	Consistency of cement	31.0%	-
2	Specific Gravity	3.41	3.15
3	Initial Setting Time	55 Mins	>30 Mins
4	Final Setting Time	275 Mins	<600 Mins
5	Fineness of cement	10%	10%
6	Compressive Strength 3 days 7 days	23.5 N/mm^2 35.8N/mm^2	23 N/mm^2 33N/mm^2

Fine Aggregates

Specific Gravity: The sand used conforms to zone III. Sieve analysis for the sand was performed and result is given in the table.

Plate No. 2: Typical View of Coarse Sand

Table 2: Sieve analysis of Fine Aggregates (Weight Taken = 1Kg)

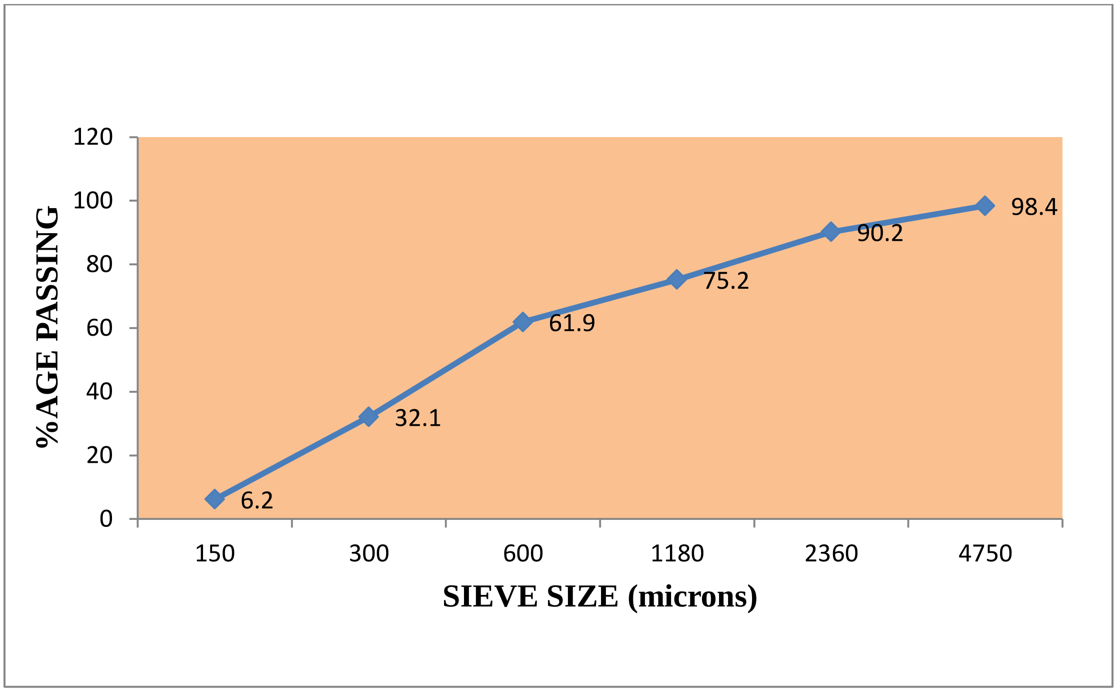
IS Sieve designation	Wt. retained on sieve (gm)	Cumulative wt. retained (gm)	Cumulative %age wt. retained	%age passing
10mm	0	0	0	100
4.75mm	16	16	1.6	98.4
2.36	82	98	9.8	90.2
1.18	150	248	24.8	75.2
600 µm	133	381	38.1	61.9
300	298	679	67.9	32.1
150 µm	257	938	93.8	6.2
<150 µm	71	1000	100	-

Fineness modulus: 2.36

Plate No. 3: Typical View of Fine Sand

Table 3: Comparison with IS: 383-1970

IS Sieve Designation	%age Passing of Sand	IS: 383-1970 Requirement for Zone III
10mm	100	100
4.75mm	98.4	90-100
2.36mm	90.2	85-100
1.18mm	75.2	75-100
600µm	61.9	60-79
300	32.1	12-40
150µm	6.2	0-10
<150µm	-	-



(Grading Curve for Fine Aggregates)

Coarse Aggregates

Maximum size of aggregates	20mm
Specific Gravity	2.67

Plate No. 4: Typical View of Coarse Aggregates

Table 4: Sieve analysis of Coarse Aggregates (Weight Taken = 5 Kg)

IS Sieve designation	Wt. retained on sieve (gm)	Cumulative wt. retained (gm)	Cumulative %age wt. retained	%age passing
80mm	-	-	-	100
40mm	-	-	-	100
20mm	-	-	-	100
10mm	4.6	4.6	92	8
4.75mm	0.34	4.94	98.8	1.2
<4.75µm	0.06	5.00	100	-

Fineness modulus: 6.9

Table 5: Comparison with IS: 383-1970

IS Sieve designation	%age passing of sand	IS 383-1970 Requirement for Zone III
80mm	100	100
40mm	100	100
20mm	100	95-100
10mm	8	0-20
4.75mm	1.2	0-5
<4.75mm	-	-

Results and Discussion

The present chapter contains the results of the tests conducted on plain and bottom ash concrete. The cubes were tested for the compressive strength and beams specimens were tested for flexural strength. Splitting tensile strength tests were conducted on cylinder specimens. The total numbers of 60 cubes, 40 beams specimens and 40 numbers of cylinders were tested for compressive strength, flexural strength and splitting tensile strength respectively at different ages to study the following aspects:

1. The effect on unit weight of concrete after incorporating varying proportions of bottom ash.
2. The effect of fly ash on workability (C.F) of fresh concrete.
3. The effect on compressive, flexural and splitting tensile strength using fly ash in varying percentages as a partial replacement of fine aggregates.

Behavior of Fly Ash Concrete

The effect is investigated on concrete using fly ash as a partial replacement of fine aggregates for the following levels:

1. Replacement of fine aggregate by 20% fly ash.
2. Replacement of fine aggregate by 30% fly ash.
3. Replacement of fine aggregate by 40% fly ash.
4. Replacement of fine aggregate by 50% fly ash.

Conclusions

- The workability of concrete decreased with the increase in fly ash content. This is considered to be due to the increase in water demand which is incorporated by increasing the content of super plastisizer.
- The density of concrete decreased with the increase in fly ash content. This is considered to be due to the low specific gravity of fly ash as compared to fine aggregates.
- Compressive strength, Splitting tensile strength and Flexural strength of fine aggregates replaced fly ash concrete specimens were lower than control concrete specimens at all the ages. The strength difference between fly ash concrete specimens and control concrete specimens became less distinct after 28 days.
- Compressive strength, Splitting tensile strength and Flexural strength of fine aggregate replaced bottom ash concrete continue to increase with age for all the fly ash contents.
- Mix containing 30% and 40% bottom ash, at 90 days, attains the compressive strength equivalent to 108% and 105% of compressive strength of normal concrete at 28 days and attains flexural strength in the range of 113-118% at 90 days of flexural strength of normal concrete at 28 days. The time required to attain the required strength is more for fly ash concrete.
- Fly ash concrete attains splitting tensile strength in the range of 121-126% at 90 days of splitting tensile strength of normal concrete at 28 days.
- Compressive strength of fly ash concrete containing 50% bottom ash is acceptable for most structural supplications since the observed compressive strength is more than 20 MPa at 28 days.
- Even though the strength development is less for bottom ash concrete, it can be equated to lower grade of normal concrete and making utilization of waste material justifies the concrete mix-development.
- Fly ash used as fine aggregates replacement enables the large utilization of waste product.

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