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"A STUDY ON PROPERTIES OF CONCRETE BY REPLACING OF FINE AGGREGATES WITH COAL FLY ASH"

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Abstract: 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, witch falls into the furnace bottom in large thermal power plants and constitute about 20% of the total ash content.

Index Terms: Characteristics,material testing,concrete mix design.

1 Introduction

Concrete- a material synonymous with strength and longevity has emerged as the dominant construction material for the infrastructure needs for the Twenty first century [1]. The Ordinary Portland Cement (OPC) is one of the main ingredients of concrete and its production involves emission of large amounts of carbon-dioxide gas into the atmosphere, a major contributor for greenhouse effect and the global warming, hence it is inevitable either to search for another material or partly replace it by some other material [2]. Fly ash, Ground Granulated Blast furnace Slag, Rice husk ash, High Reactive Metakaolin, silica fume are some of the pozzolanic materials which can be used in concrete as partial

replacement of cement [3]Addition of silica fume to concrete has many advantages like high strength, durability and reduction in cement production. When pozzolanic materials are incorporated to concrete, the silica present in these materials react with the calcium hydroxide released during the hydration of cement and forms additional calcium silicate hydrate (C
– S – H), which improves durability and the mechanical properties of concrete [4]. In this paper suitability of silica fume has been discussed by replacing cement with silica fume at varying percentages and the strength parameters were compared with conventional concrete. II

2 Materials:

The ingredient materials of concrete and their properties which are used in this study are as follows:(i) Cement: Ordinary Portland cement with Specific gravity of 3.1, (ii) Fine aggregate: Natural River sand with Specific gravity of 2.64, (iii) Coarse aggregate: 20 mm size aggregates having specific gravity 2.63 and (iv) Silica fume: also known as micro silica, is an amorphous (non-crystalline) polymorph of silicon dioxide. It is an ultrafine powder collected as a by-product of the silicon and ferrosilicon alloy production and consists of spherical particles with an average particle diameter of 150 nm. After finding the suitable mix proportion based on the material properties, the specimen of standard cube (150mm x 150mm x 150mm) and standard cylinders of (300mm x100mm) were casted to determine the compressive strength, split tensile strength of concrete with different partial replacement of silica fumes. Three specimens were tested at 7 &28 days for each proportion of silica fume replacement. Totally 30 cubes and 30 cylinders were casted for the strength parameters. The constituents were weighed and the materials were mixed by hand mixing. The water binder ratio (W/B) (Binder = Cement + Partial replacement of silica fume) adopted was 0.4. The concrete was filled in different layers and each layer was compacted by using a tamping rod. Thespecimens were demoulded after 24 hrs, cured in water for 7 & 28 days, and then tested for its compressive and split tensile as per Indian Standards.

2.1 CEMENT

Table : 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/mm2 35.8N/mm2	 23 N/mm2 33N/mm2

2.2 FINE AGGREGATES

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

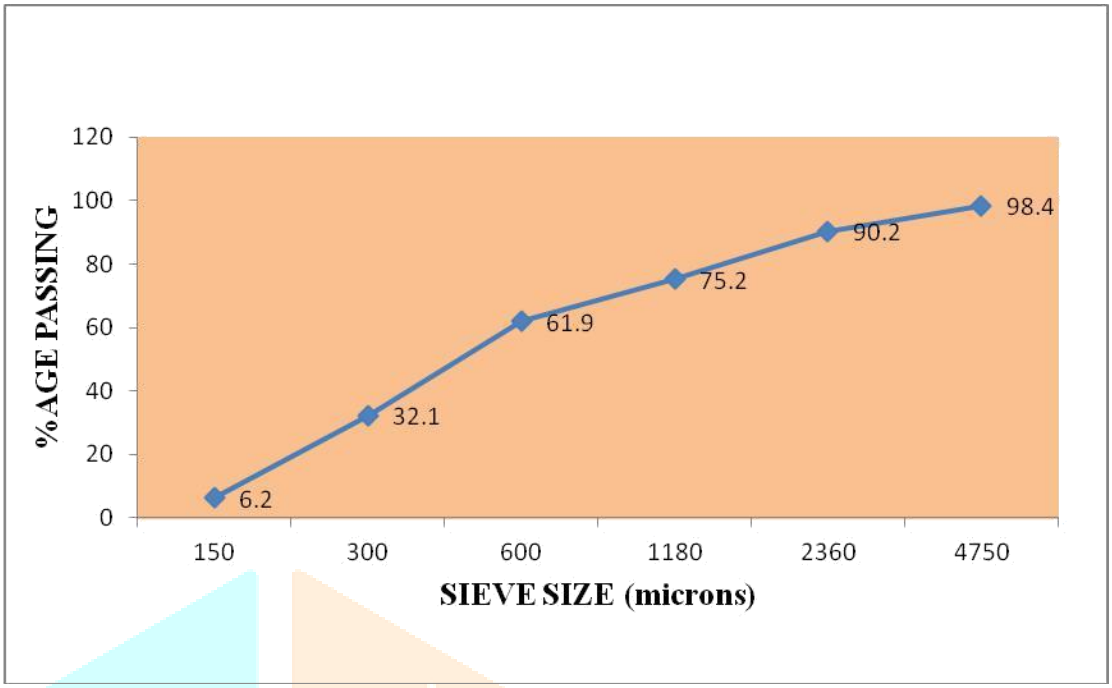
IS Sieve designation	**Wt. retained on sieve (gm)**	**Cumulative wt. retained (gm)**	**Cumulative %age wt. retained**	**%age passing**
10mm	0	0	0	100
4.75mm	16	16	1.6	98.4
2.36	82	98	9.8	90.2
1.18	150	248	24.8	75.2
600 µm	133	381	38.1	61.9
300	298	679	67.9	32.1

150 µm	257	938	93.8	6.2
<150 µm	71	1000	100	-

2.3 Fineness modulus:

Table : 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	-	-



2.4 COARSE AGGREGATES

Plate No. 4 Typical View of Coarse Aggregates

Table : 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	-

3 TEST RESULTS AND DISCUSSIONS

The present chapter contains the results of the tests conducted on plain and bottom ash concrete. The cubes were tested for compressive strength and beam 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.

4.2 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.

4.3 WORKABILITY OF FRESH CONCRETE

From the results given in Table 4.1 and fig. 4.1 , it can be seen that the workability measured in terms of compaction factor, decreases with the increase of the replacement level of the fine aggregates with the fly ash.

Table 4.1: Workability in term of Compaction Factor.

Mix Type M1 M2 M3 M4 M5 C.F. 0.90 0.87 0.85 0.84 0.82

Fig.4.1 Compaction Factor for the Fresh Concrete When the replacement level of fine aggregates is increased the extra fineness of fly ash comes into picture. The specific surface is increased due to the increased fineness and a greater amount of water is needed for the mix ingredients to get a closer packing, it results in decrease in workability of mix.

Table 4.1: Workability in term of Compaction Factor.

Mix Type	M1	M2	M3	M4	M5
C.F.	0.90	0.87	0.85	0.84	0.82

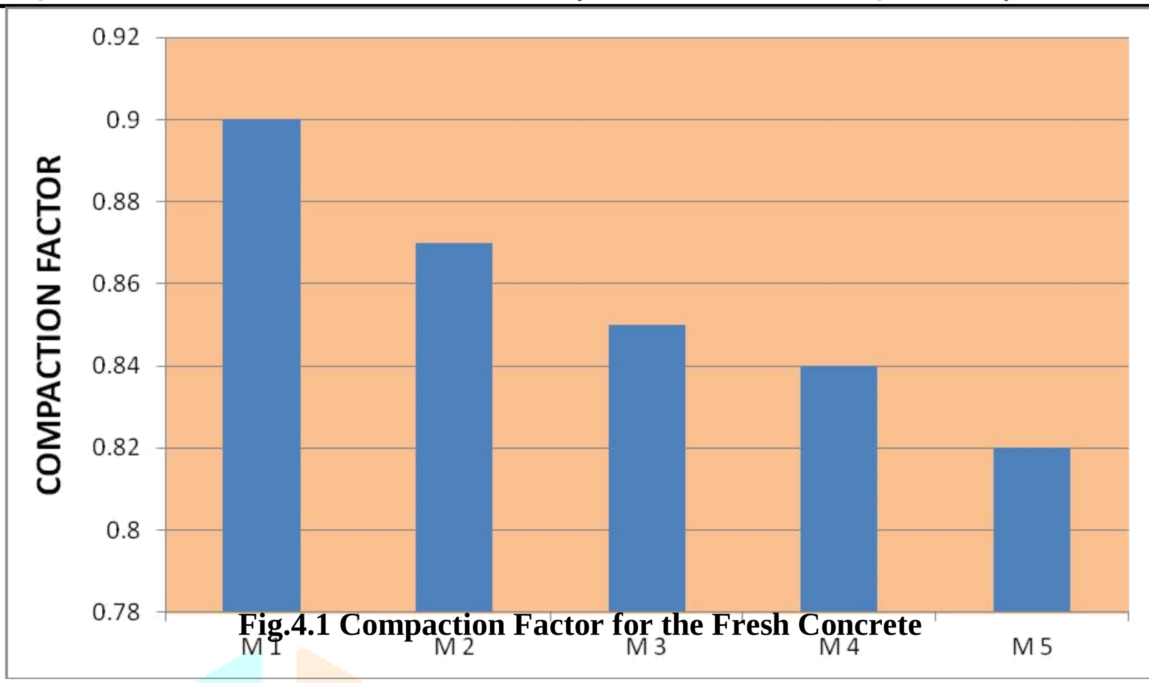


Fig.4.1 Compaction Factor for the Fresh Concrete

4 Discussions

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.

5 Conclusion

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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