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BEHAVIOR OF HIGH PERFORMANCE CONCRETE USING ALCCOFINE AND FLYASH

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Abstract: ***Concrete is backbone of construction industry and demand of rigid pavements, High rise building, and Pre-cast structure is also increasing. But manufacturing of cement in huge amount causes environmental problems like release of greenhouse gases (CO2) and depletion of natural resources. Therefore, it is necessary to use industrial by products like Fly ash, Alccofine etc. without changing engineering properties of concrete. Nowadays, most concrete mixture contains supplementary cementations materials which form part of the cementations component. These materials are majority by-products from other processes. Developing countries like India is witnessing massive construction activities in infrastructure sectors. Transport sector in particular has seen significant construction of highways, roads, ports, railways, and airports over the last decade. The vast amount of civil infrastructure in the world includes an extensive stretch of road networks. Nowadays, High performance concrete (HPC) is mostly used for highway pavements and High rise building due to its high durability even in heavy load repetitions. Due to high durability and strength, HPC demand in construction industry from railways, bridges, buildings, pavements. Pavements are important part of road infrastructure. The necessity of HPC is increasing due to its high demands in the construction industry. An extensive literature on recent research done on high performance concrete using various admixtures in different proportions to enhance physical and mechanical properties is presented with the objective of designing high performance concrete which may be utilized in Construction. This investigation deals the mechanical and rheological properties of high performance concrete with the replacement of cement with industrial by-products like Alccofine and Fly ash. The study is carried out to check the behavior of HPC using fly ash and Alccofine for Infrastructure. As Alccofine and Fly ash show cementing properties, they can be easily used for producing high performance concrete. The main aim of the study is to design M60 grade HPC according to ACI method and determine mechanical properties. Concrete is produced by blending fixed proportion of fly ash (20%) and different proportions of Alccofine (0%,3%,6%,9%,12%,15%) at water-cement ratio of 0.25. Super plasticizer (1% of cement) is added to increase the flow and to reduce water demand. The mechanical properties like compressive strength, split tensile strength and flexural strength are determined at age of 28 days. The addition of Alccofine and Fly ash is helpful in gaining strength properties and made the concrete environmental friendly without much effect on the cost.***

Keywords: Alccofine, Fly ash, Compressive strength, Split tensile strength and Flexural strength.

I. INTRODUCTION

In construction industry Concrete is an important structural material. The concrete is regarded as one of the best construction material in the present scenario. The progress of concrete industry also gives to many other nature problems like pollution, dumping of waste materials, emission of greenhouse gases (CO2), depletion of vegetation and natural resources. These days, Ordinary Portland Cement (OPC), binding materials and other materials are available that increase the performance of concrete. The production of each ton of cement, about 1 ton of CO2 is generated. Then, cement production plays an important role in generation of greenhouse gases that share about 5 percent of total CO2 emissions. In USA and UK are aware of these situations and have also introduced taxes on climate changes to reduce carbon emissions. Therefore, the concept of sustainable development is introduced with the aim of using industrial waste products for enhancement of concrete properties. These industrial wastes or by-product plays very important role in development of concrete industry, giving the most suitable, economical and technical solutions for waste disposal resulting in less harm to the nature. These by-products and wastes can be used as partial replacement for cement making these as important constituents of concrete.

II. MATERIALS

2.1. Cement – There are three grades (33, 43, and 53) of cement available generally in market. Ordinary Portland cement grade 53 of Ambuja brand at Gujarat are used in HPC conforming to IS: 269-2015. The physical and chemical properties of cement are listed in the Table below.

Physical properties of Cement

Sr.No.	Physical properties	Results
1	Specific Gravity	3.15
2	Fineness Test	1%
3	Consistency Test	31%
4	Initial setting time	135 min
5	Final setting time	215 min
6	Soundness Test	1 mm
7	Compressive strength in Mpa	
	3 Days (avg. of 3)	42.6 Mpa
	7 Days (avg. of 3)	54.2 Mpa
	28 Days (avg. of 3)	65.8 Mpa

Chemical properties of Cement

SL.NO:	TEST CONDUCTED	Results in %
1	SiO_2	20.41
2	Al_2O_3	5.29
3	Fe_2O_3	3.83
4	CaO	63.20
5	MgO	1.14
6	SO_3	2.96
7	LOI	1.15
8	Chloride content	0.039
9	C_3A	7.55

2.2. Fly Ash – Fly Ash is the industrial by-product produced by electrostatic process from flue gases of power station furnaces fired with coal. According to ASTM C 618-99, FA is classified into 2 classes i.e. Class F and Class C. Fly ash used in this investigation Class C and Gandhinager source Gujarat. The characteristic of Fly ash showing pozzolanic property similar to cement has motivated the use of Fly Ash as partial replacement of cement in concrete. The physical and chemical properties of Fly Ash are listed in the Table.

Physical and Chemical Properties of Fly Ash

Sr.No:	TEST CONDUCTED	RESULTS IN %
1	Al_2O_3	19.31
2	CaO	11.27
3	Fe_2O_3	13.37
4	LOI	0.11
5	MgO	4.32
6	SiO_2	45.30
7	SO_3	1.08
8	Specific Gravity	2.6
9	Fineness	7.69

2.3. Alccofine - Alccofine is new generation product with ultrafine size having less calcium silicate content, easily available in India. It has characteristics to improve the performance of concrete in both fresh and hardened phases. Alccofine shows better properties than other admixtures used in India. Alccofine is used for concrete mixture which possess high workability, high strength, and high modulus of elasticity, high density, high dimension stability, low permeability and resistant to chemical attack. Various properties of Alccofine are presented in below table. The Alccofine 1203 is used in the experiment from Ambuja cement from Gujarat.

Physical & chemical properties of Alccofine 1203

Sr. No:	Chemical Analysis	Mass %	Physical Analysis	Values
1	CaO	32-34	Bulk density	600-700kg/m^3
2	Al_2O_3	18-20	Surface area	12000cm^2 /gm
3	Fe_2O_3	1.8-2	Particle shape	Irregular
4	SO_3	0.3-0.7	Particle size, d10	<2 µ
5	MgO	10-Aug	d50	<5 µ
6	SiO_2	33-35	d90	<9 µ

2.4. Fine Aggregate – Material passing through an IS sieve 4.75mm is called as fine aggregate. The locally Crushed sand available confirming to Zone-II as per IS 383-1970 is used as fine aggregate.

Physical properties of Fine Aggregate

Sr. No.	Physical properties	Results
1	Fineness Modulus	2.881
2	Density	1623
3	Specific Gravity	2.62

2.5 Coarse Aggregate – Materials retained on IS sieve 4.75mm is called as coarse aggregate. To produce high strength concrete, it is very important to select proper material, locally available aggregates of maximum 20mm size is used. Testing of materials is done according to IS Codes procedures and the results are shown in the table and locally available crushed rock Aggregate was used in the investigation.

Physical properties of 20mm Aggregate

Sr. No.	Physical properties	Results
1	FI+EI in %	37.31
2	Crushing Value	21.24
3	Impact Value	14.39
4	Fineness Modulus	1.90
5	Specific Gravity	2.76

Physical properties of 10mm Aggregate

Sr. No.	Physical properties	Results
1	FI+EI in %	37.31
2	Specific Gravity	2.76

2.6. Water – Water is an important ingredient in preparation of concrete. Potable water free from deleterious materials, odorless, normal appearance oils, salts with normal temperature is used mixing and curing in this experiment.

Physical and chemical properties of water

Sr.No:	Test Conducted	Results
1	pH Value	6.7 mg/L
2	CaCO3	64 mg/L
3	Chloride	71.47 mg/L
4	Total Dissolved Solids	46 mg/L

2.7. Super plasticizer - CAC-HYPERFLUID PLUS (H5) a concrete super plasticizer based on Poly carboxylic ether is used as a water-reducing admixture and to improve the workability of admixed concrete. CAC-HYPERFLUID PLUS (H5) has been specially formulated to give high water reductions up to 40% without loss of workability or to produce high quality concrete of reduced permeability.

Physical and Chemical properties of Super plasticizer

Sr.No:	Parameter	Results
1	Appearance	Colourless liquid
2	Base material	Mid PC polymer
3	Sp. gravity	1.1
4	PH	6.6
5	Solid content (%)	34.4
6	Chloride content (%)	Nil
7	Ash content	3.2

III. MIX DESIGN M60 GRADE CONCRETE

This research study depends upon two factors to produce HSC, i.e. the use of SCMs for same W/C ratio in HPC. This research study is commenced by identifying the optimum Concrete mix design of HPC using SCM. Alccofine varies from 3 to 15% and fly ash will be constant 20%. The water/binder ratio for these mix used are taken low. The final amount of materials (kg/m^3) taken after several controlled mixed trials in the concrete. Six cube samples each for 7 days and 28 days testing are casted and designated M0 to M5.

Sr. No.	Material	Volume (Kg/m3)
1	Cement	400
2	Fly ash	108
3	10mm	536
4	20mm	655
5	Crushed sand	631
6	Water	146
7	Admixture	5.4

IV. RESULTS

4.1. Compressive Strength - Compressive strength is calculated on an average of three cubes for every concrete mix for 7 & 28 days as per IS: 516-1959. After curing of 28 days with proper drying, the cube samples are placed between the bearing plates of the CTM. The samples are carefully kept at center of bearing surfaces and load is applied continuously at rate of approximately 140kg/cm2 /min until the sample fails. The load is recorded at failure of cube specimen. The compressive strength of the sample can be calculated and result expressed as N/mm2.

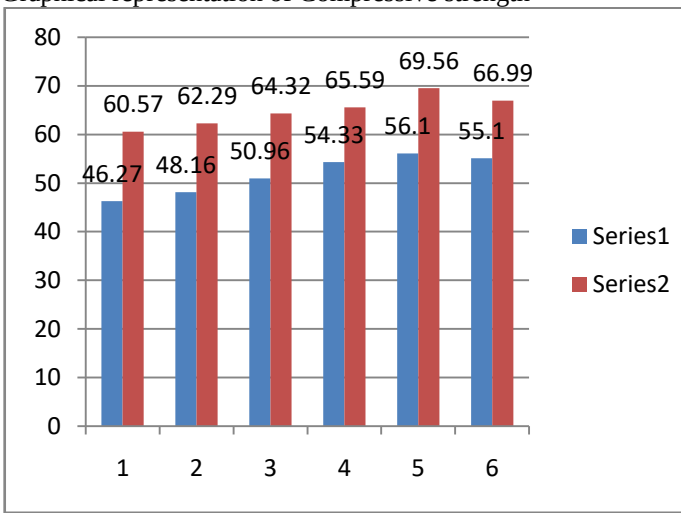
Compressive strength after 7 days.

Mix Designation	% of Alccofine	Average strength (N/mm2)
M0	0	46.27
M1	3	48.16
M2	6	50.96
M3	9	54.33
M4	12	56.10
M5	15	55.10

Compressive strength after 28 days.

Mix Designation	% of Alccofine	Average strength (N/mm2)
M0	0	60.57
M1	3	62.29
M2	6	64.32
M3	9	65.59
M4	12	69.56
M5	15	66.99

Graphical representation of Compressive strength



4.2. Split tensile strength - The test specimen is placed in the machine along the perpendicular axis of loading of the specimen. The central jig is placed in the machine so that the specimen is located centrally. The load is applied increased continuously at rate of 1.2 N/ (mm^2 /min) to 2.4 N/ (mm^2 /min). The maximum load applied when it failed is recorded. Tests are conducted according to IS: 5816-1999. The tensile strength is calculated on mix for 28 days.

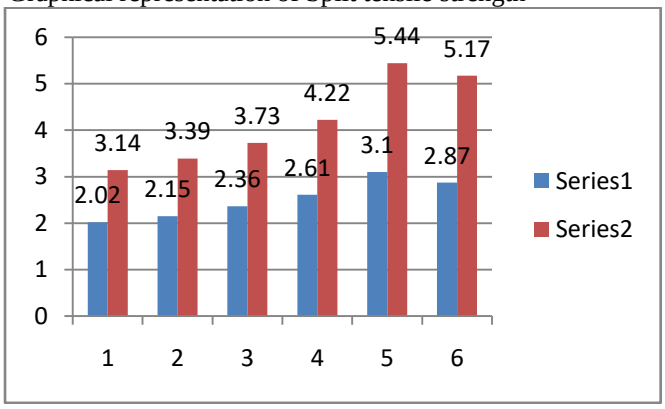
Split tensile strength after 7 days.

Mix Designation	% of Alccofine	Average strength (N/mm2)
M0	0	2.02
M1	3	2.15
M2	6	2.36
M3	9	2.61
M4	12	3.1
M5	15	2.87

Split tensile strength after 28 days.

Mix Designation	% of Alccofine	Average strength (N/mm2)
M0	0	3.14
M1	3	3.39
M2	6	3.73
M3	9	4.22
M4	12	5.44
M5	15	5.17

Graphical representation of Split tensile strength



4.3. Flexural strength - Flexural testing machine is used for calculating flexural strength of concrete. The beams of size 700 × 150 × 150 mm are used for measuring flexural strength. The procedure is as per IS 516-1959. The bearing surfaces of the supports and loading rollers should be free from any harmful materials. The specimen is placed in the machine and load is applied. The load is applied without any jerk at a rate of loading 1.76 kN/min. The load is increased, till the specimen fails, and the maximum load applied to the specimen during the test is recorded. The value of flexural strength is taken as average of three samples.

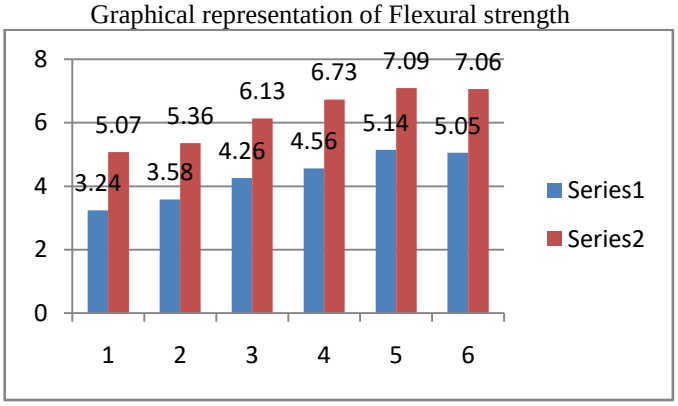
Flexural strength after 7 days.

Mix Designation	% of Alccofine	Average strength (N/mm2)
M0	0	3.24
M1	3	3.58
M2	6	4.26
M3	9	4.56
M4	12	5.14
M5	15	5.05

Flexural strength after 28 days.

Mix Designation	% of Alccofine	Average strength (N/mm2)
M0	0	5.07
M1	3	5.36
M2	6	6.13
M3	9	6.73
M4	12	7.09
M5	15	7.06

Graphical representation of Flexural strength



V. CONCLUSION

Laboratory tests are performed covering the mechanical and rheological aspects of high performance concrete. The major experimental conclusions of this thesis are as follows;

- High performance concrete is modified by blending with Fly Ash and Alccofine as Supplementary Cementations material. These adjustments reduce the CO2 emission and make concrete eco-friendly.
- From compressive strength of various mix proportions by considering all available Supplementary Cementations Materials, it is found that mix incorporating fly ash and Alccofine has given good results.
- The minimum and maximum compressive strength attained at 28 days of curing were found to be 60.57 N/mm2 and 69.56 N/mm2 respectively.
- The compressive strength of concrete is increased with increase in Alccofine content up to 12%. It is therefore concluded that there is possibility of production of concrete having compressive strength more than 60 MPa from mix incorporating Alccofine and fly ash as SCM at 0.25w/c ratio based on investigation. The utilization of fly ash and Alccofine in mix has shown substantial improvement in strength characteristics of HPC.
- There is considerable improvement in flexural behavior of concrete mix having fly ash and Alccofine. The maximum flexural strength obtained is 7.09 MPa.
- The minimum and maximum split tensile strength attained at 28 days of curing is found to be 3.14 N/mm2 and 5.44 N/mm2 respectively. High strength achieved through the use of SCMs decreases the maintenance cost of structure.
- When using a super plasticizing admixture with HPC made with aggregates, adding of admixture in final stage of mixing consistently improves the properties of fresh and hardened concrete compared with the traditional practice of adding the admixture to the mixing water.
- The cube compressive strength studies indicate that the optimum percentage of Alccofine is about 12%. The density of HPC increases as Alccofine content increases.

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