An experimental study on high performance concrete using mineral admixtures

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Abstract **--This paper presents study the effect of performance of HPC using mineral admixture i.e. fly ash and GGBS with M-60 grade of IS cube specimen .We partially replaced Portland cement by weight of binder. Fly ash and GGBS replacement varies from 10% to 30%. We used Conplast SP430-Sulphonated Naphthalene Polymers as a superplasticizer for better workability for high performance concrete. Dosage for superplasticizers is same for all mix proportions. Also, we have replaced fine aggregate in different proportions with foundry sand. We have investigated compressive strength, split tensile strength and flexural strength for all different cases. The HPC mix, grade M60concrete is designed as per Indian standards "Guide for selecting proportions for high strength concrete with Pozzolana Portland cement and other cementitious materials".**

***Index Terms*—high performance concrete, mineral admixtures, superplasticizers, foundry sand etc.**

I. INTRODUCTION

Concrete is the most widely used construction material all over the world in view of its strength, high mould ability, structural stability and economic considerations. High performance concrete (HPC) is a concrete that meets special combinations of performance and uniformity requirements which cannot always be achieved routinely using conventional constituents and normal mixing and placing and curing practices. To produce high performance concrete it is generally essential to use chemical and mineral admixtures in addition to the same ingredients, which are generally used for normal concrete. In recent times, many researches are going on for improving the properties of concrete with respect to strength, durability, and performance as a structural material. There are many materials like fly ash, furnace slag, foundry sand and silica fume, metakaolin, stone dust, manufactured sand etc.

Salient features of HPC

- ✓ Wide range of grain sizes.
- ✓ Reduced flocculation of cement grains.
- ✓ Densified cement paste.
- ✓ Endogenous shrinkage.
- ✓ Low free lime content.
- ✓ Stronger transition zone at the interface between cement paste and aggregate
- ✓ Discontinuous spores.
- ✓ Less capillary porosity.
- ✓ No bleeding homogeneous mix.
- ✓ Smooth fracture surface.

II. AIM AND OBJECTIVE

Aim of the study

The main aim of this project is to study the properties and durability characteristics of fresh and hardened concrete using fly ash, GGBS and replacement of fine aggregate with foundry sand in high performance concrete of M60 grade.

Objectives

- ✓ To achieve the desire strength in high performance concrete.
- ✓ To find out the dosage of the fly ash and GGBS at which the concrete gain the higher strength.
- ✓ Determination of the compressive strength, split tensile strength, and flexural strength of the concrete.
- ✓ To find out the percentage at which the foundry sand is replaced and gain the optimum strength as well as workability.
- ✓ Foundry sand is also industrial waste by the use of it we can reduced the environmental degradation.

III. REVIEW OF LITERATURE

Muthukumar T and Sirajudeen K (January 2016), "Experimental investigation on high performance concrete using alternate materials"

They performed the experimental investigation on high performance concrete using M50 grade mix proportion. High performance concrete achieved by, 100% replace the fine aggregate by crusher wash sand and partial replacement of cement by micro silica (i.e., 5%, 10%, 15%, 20% & 25%). Glenium b233 were added for workability of concrete mix. A result data obtained has been analyzed and compared with a control specimen. A relationship between Compressive strength vs. days, Tensile strength vs. days, and Flexural strength vs. days represented graphically. Result data clearly shows percentage increase in 7 and 28 days Compressive strength, Tensile strength and Flexural strength for M-50 Grade of Concrete. Combination of micro silica, crusher wash sand and super plasticizer in this experimental study show a great improvement in the compressive strength as well as tensile properties .Cement was replaced by micro silica by 20%, however strength increases by 16.5%. High Performance Concrete strength is achievable using micro silica.

M.Ranjitham and Vennila (2014), "Experimental Investigation on High Performance Concrete with Partial Replacement of fine aggregate by Foundry Sand with cement by Mineral Admixtures"

They have prepared this paper based on the experimental investigation of high performance concrete wit partial replacement of fine aggregate by foundry sand with cement by mineral admixtures. In this project, investigations were carried out on strength properties such as compressive strength, split tensile strength and flexural strength of M75 grade of HPC mixes with different replacement levels such as 10%, 20%, and 30% of foundry sand with fine aggregate and 10%, 20%, 30% and replacing cement by mineral admixtures such as fly ash and ground granulated blast furnace slag by adopting water-binder ratio of 0.3. Conplast SP430 is based on Sulphonated Napthalene Polymers can be used as a super plasticizer for better workability for high performance concrete.In this study it has been found that adding optimum superplasticizers dosage the workability is reached. So that the required slump value can be obtained for HPC. The slump value for M75 grade using foundry sand and fly ash is reduced. For 30% fly ash and 30% GGBS replacement, the fresh properties observed were good as compared to 10%, 20% replacement.The presence of foundry sand and mineral admixtures increasing the compressive strength and also withstanding the maximum load. Compare to fly ash GGBS attains good strength as cement replacement.

Mr. Sabale Vishal Dhondiram et al (2009), "Experimental Study on High Performance Concrete"

In this paper they researched the results of study on silica fume based high-performance concrete. The attempt has been made to compare, the 7 days and 28 days compressive strength, splitting tensile strength and flexural strength of concrete by using silica fume with the normal concrete of m60 grade with maintaining the water cement ratio 0.3. The objective of this study is to develop concrete with good strength, less porous, less capillarity, so that durability will be reached. For this purpose, the experiment has been carried out on m60 grade of concrete, using silica fume in different percentage 0%, 5%, 10%, 15% to the weight of cement. The maximum replacement level of silica fume is 10% for M60grade of concrete. Use of silica fume gives significant result on properties of concrete as compared to normal concrete.

Asma.K.C and Preetha Prabhakaran (24th-25th January 2014), "Effect of Mineral Admixtures on Durability Properties of High Performance Concrete"

The improved pore structure of HPC is mainly achieved by the use of chemical and mineral admixtures. In the present study the effect of mineral admixtures on the durability properties of HPC is investigated. A control mix without any mineral admixtures having a compressive strength was designed of 60MPa and two other mixes are prepared one by replacing cement by 10% metakaoline and other by replacing cement with 10% metakaoline + 30% fly ash respectively The workability tests were carried out on the fresh mix . The compressive strength at 56 day and 90 day acid exposure the rate of strength loss was minimum for HPMF mix followed by HPM mix and HPCL mix respectively for both curing condition. In the case of sulphate attack test the strength loss percentage was reduced by the addition of mineral admixtures. Comparing the strength corresponding to 56 and 90 day sulphate exposure the rate of strength loss was found to be minimum for HPMF mix for both curing condition. The results from rapid chloride permeability test have shown that the chloride penetration resistance was increased by addition of mineral admixture for both 56 and 90 day water curing. HPMF mix has highest chloride penetration resistance followed by HPM mix and HPCL mix.

IV. MATERIALS AND METHODS

To evaluate the high strength concrete compressive strength, split tensile strength, and flexural strength have been studied in this investigations.

Materials: High performance concrete was made of cement, sand, fly ash, GGBS, foundry sand, aggregate, water and chemical admixture.

1) Cement: Ordinary portland cement, 53 grade conforming to IS: 12269-1987.
2) Sand: Locally available sand confined to zone II of IS: 383-1970.

Table No 1: Chemical Properties of Fly Ash

Sr. no	Types of test	Test method standard	Results obtained
1	CaO (%)	IS-1727	0.50
2	SiO2 (%)	IS-1727	67.60
3	Al2O3 (%)	IS-1727	11.30
4	MgO (%)	IS-1727	0.10
5	SO3 (%)	IS-1727	0.060
6	Na2O (%)	IS-4032	0.035
7	K2O	IS-4032	0.005
8	Total chloride (%)	IS-12423	0.008
9	Loss of ignition (%)	IS-1727	2.60
10	Fe2O3 (%)	IS-4031	1.15
11	TiO2 (%)	IS-4031	Nil
12	P2O3 (%)	IS-4031	0.0002

4) GGBS:
The purpose of the experimental work is to investigate the effects of addition of ground granulated blast furnace slag (GGBS) to local soil on various geotechnical properties like; Gain size distribution, Atterberg limits, Swelling pressure, California Bearing Ratio etc., and also to investigate its utilization a sub grade, embankment for the highway construction .GGBS was collected from the Astrox cement, Kim, Gujarat. Local soil was collected from the College Campus

Table No 2: Physical Properties of GGBS

Physical Properties	GGBS
Colour	Off-White
Specific gravity	2.9
Bulk density	1200 kg/m^3
Fineness	>350 m^2/kg

5) COARSE AGGREGATE:
Aggregates are the important constituents in concrete. They give body to the concrete, reduce shrinkage and effect economy. Earlier, aggregates were considered as chemically inert materials but now it has been recognized that some of the aggregates are chemically active and also that certain aggregates exhibit chemical bond at the interface of aggregate and paste. The mere fact that the aggregates occupy 70–80 per cent of the volume of concrete, their impact on various characteristics and properties of concrete is undoubtedly considerable. To know more about the concrete it is very essential that one should know more about the aggregates which constitute major volume in concrete. Without the study of the aggregate in depth and range, the study of the concrete is incomplete. Cement is the only factory made standard component in concrete. Other ingredients, namely, water and aggregates are natural materials and can vary to any extent in many of their properties. The depth and range of studies that are required to be made in respect of aggregates to understand their widely varying effects and influence on the properties of concrete cannot be underrated.

6) Water: Fresh, odorless, colorless and tasteless water free form any organic matter was used. Water is an important ingredient of concrete as it actively participates in the chemical reaction with cement. Since it helps to form the strength giving cement gel, the quantity and quality of water is required to be looked into very carefully. It has been discussed enough in chapter about the

quantity of mixing water but so far the quality of water has not been discussed. In practice, very often great control on properties of cement and aggregate is exercised, but the control on the quality of water is often neglected. Since quality of water affects the strength, it is necessary for us to go into the purity and quality of water.

7) Chemical admixture: They are chemically different from normal plasticizers. Uses of superplasticizers permit the reduction of water to the extent up to 30 per cent without reducing workability in contrast to the possible reduction up to 15 per cent in case of plasticizers.
The use of superplasticizers is practiced for production of flowing, self-levelling and self-compacting and for the production of high strength and high performance concrete. The mechanisms of action of superplasticizers are more or less same as explained earlier in case of ordinary plasticizer. Only thing is that the superplasticizers are more powerful as dispersing agents and they are high range water reducers. They are called High Range Water Reducers in American literature. It is the use of superplasticizers which has made it possible to use w/c as low as 0.25 or even lower and yet to make flowing concrete to obtain strength of the order 120 MPa or more. It is the use of superplasticizers which has made it possible to use fly ash, slag and particularly silica fume to make high performance concrete.
8) Foundry sand: - A foundry is a manufacturing facility that produces metal castings by pouring molten metal into a preformed mould to yield the resulting hardened cast. The primary metals cast include iron and steel from the ferrous family and aluminium, copper, brass and bronze from the nonferrous family.

Foundry sand is high quality silica sand that is a by-product from the production of both ferrous and nonferrous metal castings. The physical and chemical characteristics of foundry sand will depend in great part on the type of casting process and the industry sector from which it originates. Metal foundries use large amounts of sand as part of the metal casting process. Foundries successfully recycle and reuse the sand many times in a foundry. When sand can no longer be reused in the foundry, it is removed from the foundry and is termed "foundry sand." Foundry sand production is nearly 6 to 10 million tons annually.
Like many waste products, foundry sand has beneficial applications to other industries. Foundries purchase high quality size-specific silica sands for use in their mouldings and casting operations. The raw sand is normally of a higher quality than the typical bank run or natural sands used in fill construction sites.

Methods:-

a) Compressive strength test: Concrete cubes 150*150*150 mm were casted and tested at 7, 28, and 56 days as per IS: 516 - 1959 and average compressive strength is reported.
b) Split tensile strength test: Concrete cylinders of size 150 mm diameter and 300 mm height were casted and tested at 28 days and 56 days as per IS: 5816-1999 and average split tensile strength is reported.
c) Flexural strength test: Concrete beams of size 500*500*700 mm were casted and tested for 28 days as per IS: 516 - 1959 and average flexural strength is reported.

Mix Proportions

Table No 3: Mix Proportions

PROPORTION	FS% BY FA	FA BY % OF CEMENT	GGBS BY %OF CEMENT	7-DAYS STRENGTH (MPA)	14-DAYS STRENGTH (MPA)	28-DAYS STRENGTH (MPA)
M1	10	10	0	29.6	36	60
M2	20	20	0	29.6	40	61.6
M3	30	30	0	33.6	43.2	63.2
M4	10	0	10	36	40.8	68.8
M5	20	0	15	34.4	44	66.4
M6	30	0	20	32.8	42.4	65.6

V. RESULTS AND DISCUSSION

Effect on workability

Table No 4: Workability

TEST RESULTS OF WORKABILITY			
	M1	M2	M3
Slump(mm)	57	58	60
Compaction factor	0.91	0.89	0.92

Effect on Compressive Strength

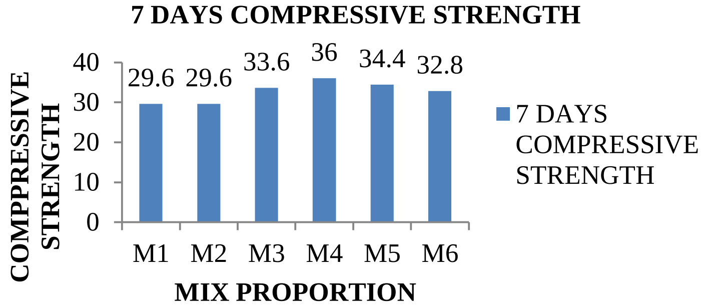

Figure 1: 7 Days Average Compressive Strength

Figure 1 shows that the compressive strength of concrete is maximum achieved in the M4 mix proportion which is 36 MPa.

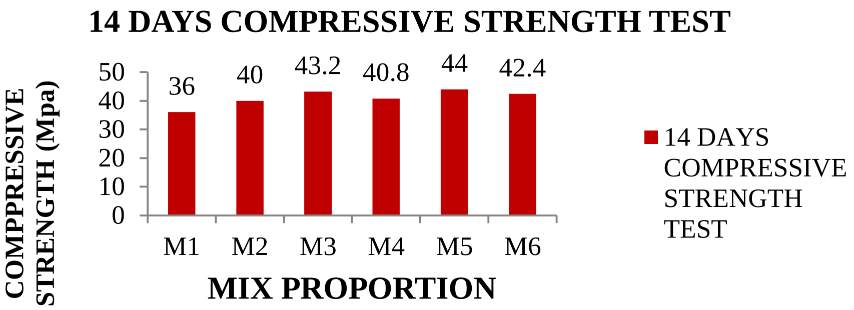

Figure2:14 Days Average Compressive Strength

Figure 2 shows that the compressive strength of concrete is maximum achieved in the M5 mix proportion which is 44 MPa.

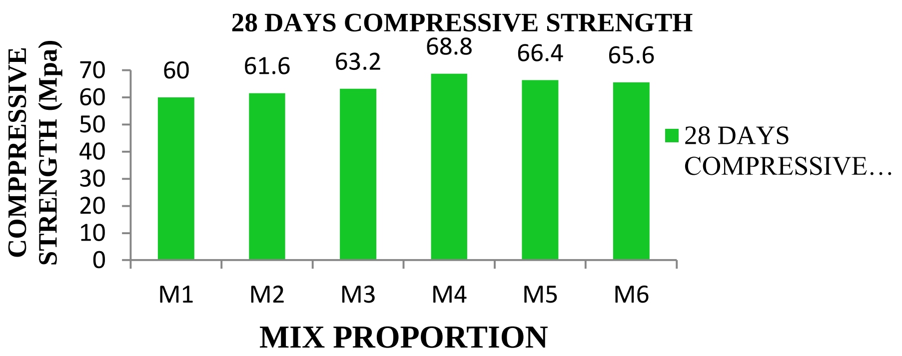

Figure 3:28 Days Average Compressive Strength

Figure 3 shows that the compressive strength of concrete is maximum achieved in the M5 mix proportion which is 68.8 MPa.

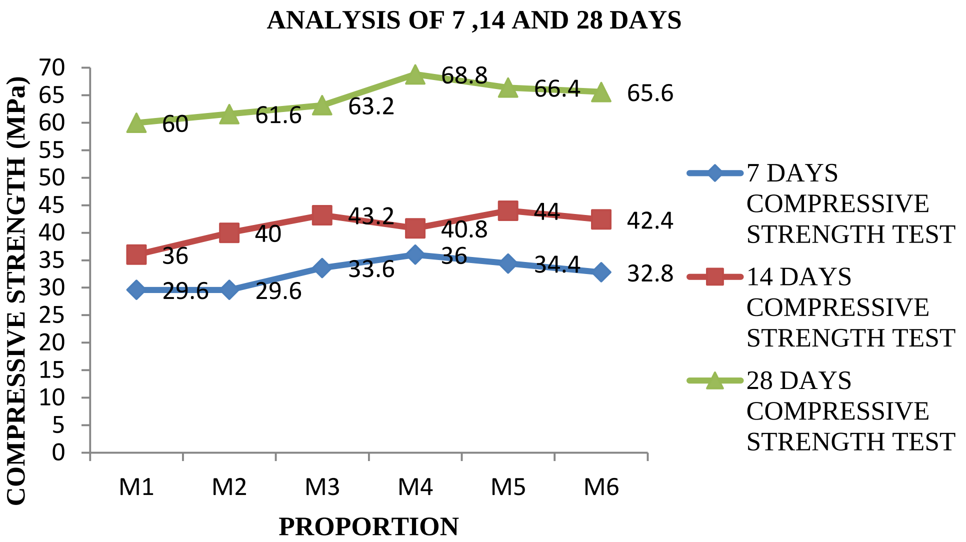

Figure 4: Comparison between 7,14and 28 Days Strength

Figure 4 shows that the compressive strength of concrete is maximum achieved at 28 days and the strength is increased between 14 to 28 days was maximum.

Effect on Split Tensile Strength

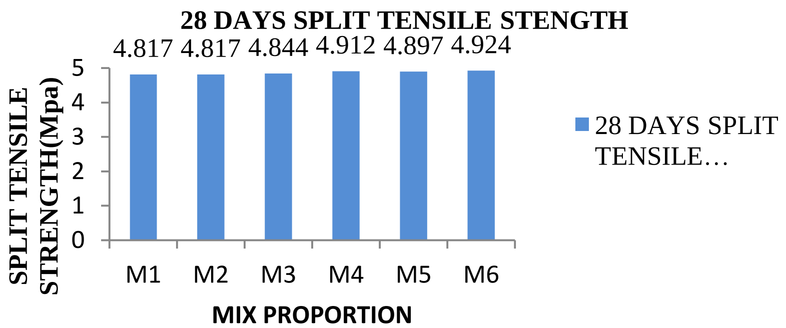

Figure 5:*28 Days Split Tensile Strength*

Figure5 shows that the split tensile strength of concrete is maximum achieved at 28 days was 4.924 MPa.

Effect on Flexural Strength

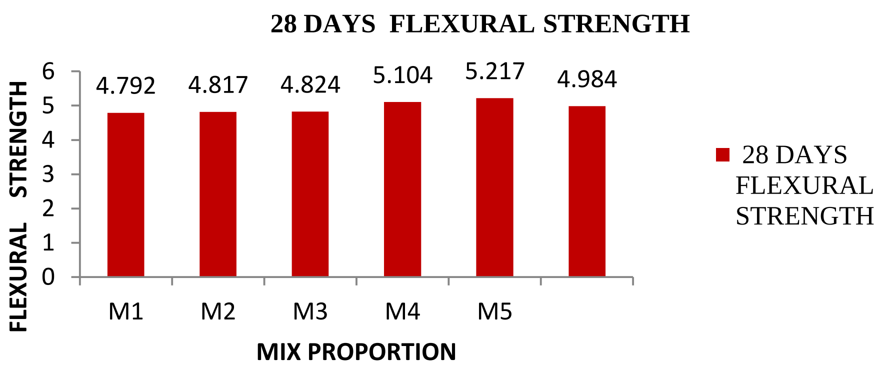

Figure 6:28 Days flexural strength

Figure 6 shows that the flexural strength of concrete is maximum achieved at 28 days was 5.217 MPa.

VI. CONCLUSION

- Compressive strength for concrete with replacement of natural sand of foundry sand 10, 20, and 30% and cement by mineral admixtures is fly ash10, 20, and30% and GGBS is 10, 15 and 20%.
- The compressive strength continue to increase as the curing period increase and greatest compressive strength is achieved when mixture content 30% of fine aggregate replaced with foundry sand and 10% GGBS.
- We observed that development of tensile strength increase as replacement of sand by 10% of GGBS gives higher strength compared to control mix.
- Maximum compressive strength is achieved in M4 mix proportion, ggbs 10% replaced by the cement and FS is 10% replaced by the fine aggregate and the strength gained 68.8 MPa.
- Maximum split strength is achieved in M6 mix proportion, ggbs 20% replaced by the cement and FS is 30% replaced by the fine aggregate and the strength gained 4.924 MPa.
- Also maximum flexural strength is achieved in M4 mix proportion, ggbs 10% replaced by the cement and FS is 10% replaced by the fine aggregate and the strength gained 5.104 MPa.
- In all mix proportion strength gain up is excellent, but 14 days compressive strength is less, and for 28 days strength gain is high because of combination of fly ash and GGBS.

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