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Development of M60 Grade of Concrete using Micro-Silica and Alccofine Separately for the Construction of Bridge Girders

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Abstract: ***The necessity of high-performance concrete is increasing because of demands in the construction industry basically in important structures such as bridge construction and high-rise buildings, dams, girders etc. Efforts which are made for improving the performance of concrete over the past few years suggest that cement replacement materials along with mineral and chemical admixtures can improve the strength and durability characteristics of concrete. Alccofine and micro-silica are supplementary cementitious materials that can be utilized to produce highly durable concrete which gives better result than that of the ordinary concrete. This study investigates the performance of high strength concrete of M60 grade in terms of Compressive strength, temperature, slump, etc. In addition, find out the optimum dosage of Alccofine and micro silica from given mix proportion to increase the strength of the concrete. Our aim of study is to compare the performance of concrete containing supplementary cementitious materials such as Micro silica, Alccofine and GGBS which helps in increasing the strength, durability and also reduce the quantity of cement in concrete mix.***
Keywords: ***High Strength Concrete, Supplementary Cementitious Materials, Alccofine, Micro-silica, GGBS, carbon inhibitors***

I. INTRODUCTION

A. General

In today's world of construction economy and strength both are important parameter to be considered in High performance concrete. The necessity of high-performance concrete is increasing because of demands in the construction industry. High strength concrete is mostly used in the structure like bridges, pylon, Girders, Dams etc.

B. Concrete

In Concrete cement, fine aggregates and coarse aggregates are the main construction material in which water is mixed in proper ratio to gain desired strength and hardness. The most important term for concrete is compressive strength. When concrete gets hardened it must have some appropriate compressive strength which enable the concrete to resist the load and forces applied on it. Plain concrete construction and reinforced construction are the types of construction in which concrete is generally used.

On the basis of the concrete strength in 28 days with proper curing concrete can be divided into following 3 types:

1) Nominal concrete (range from M5 to M20)
2) Standard concrete (range from M25 to M45)
3) High strength concrete (range from M50 to M90)

C. Supplementary Cementitious Materials

In order to reduce the amount of cement in concrete without affecting strength, Supplementary cementitious materials (SCMs) are widely used in concrete mix. These materials are often added to concrete to make concrete mixtures reduce permeability, more economical, increase strength, or influence other concrete properties.

In present study following types of Supplementary cementing material are used.

1) *Ground-Granulated Blast Furnace slag (GGBS):* GGBS is a type of Supplementary cementing material which is obtained in a form of slag a blast furnace as a by-product of iron and steel-making from in water or steam. The slag is then dried and ground into a fine powder. GGBS is used as a direct replacement for cement, according to the basis by weight. Replacement levels for GGBS vary according to the requirement mostly 40% to 50%. It also cheaper than that of cement. The use of GGBS in concrete also helps in reduce the risk of reinforcement corrosion significantly by providing higher resistance to chloride ingress and by alkali–silica reaction in the concrete, it also provides higher resistance to attacks by sulfate and other chemicals. Because of its cheaper rates than concrete it is more economical to use

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TABLE 1.1 Chemical Composition of GGBS

Physical properties of GGBS	
specific gravity	2.87
Bulk density	1200 Kg/m^3
Fineness	1200 Kg/m^3
Chemical properties of GGBS	
CaO	40%
Sio2	35%
AL2O3	12%
Fe2O3	0.20%
MgO	10%

2) *Micro-Silica:* PCV Micro silica is also known as silica fume. Micro silica is finely divided powder or a material which come from the production of elemental silicon or ferro-silicon alloys. It is very fine with particles size less than 1 micron. Micro silica, with or without fly ash or slag, is often used to make high-strength concrete. The physical appearance of micro-silica is black in colour.

TABLE 1.2 Chemical Composition OF Micro-Silica

Chemical Requirement	Percentage Analysis
SIO2	88.25%
Loss of Ignition	1.26%
Moisture content	0.38%
Physical requirement	Percentage Analysis
Bulk Density	615kg/m^3
Pozz. Activity Index(7d)	126.00%
>45micron	1.18%

3) *Alccofin:* Alccofine is a micro fine material of new generation which is having particle size much finer than other supplementary cementing materials like fly ash, silica etc. being manufactured in India. because of its optimized particle size distribution Alccofine has unique characteristics to increase the performance of concrete in both the fresh and hardened stages. It can also be used as substitute for Micro Silica in concrete as it has optimum particle size distribution.

There are two types of Alccofine:

a) *Alccofine 1101:* It is an Alccofine with high calcium silicate. The performance of Alccofine is superior to all other SCMs used in India. Due to high calcium oxide (Cao) content.

b) *Alccofine 1203:* It is an Alccofine with low calcium silicate. Alccofine 1200 series is of 1201, 1202, 1203 which represents fine, micro fine, ultrafine particle size respectively. Alccofine 1203 is a slag-based SCMs which is having ultra-fineness with optimized particle size distribution. Alccofine 1203 provides reduced water demand for a given workability, even up to 70% replacement level as per requirement of concrete performance.

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Table 1.3 Chemical Composition of Alccofine

Chemical Requirement	Percentage Analysis
SIO2	33.70%
MgO	6.10%
Fe2O3	1.60%
Al2O3	22%
SO3	0.12%
CaO	34.30%
Physical requirement	Percentage Analysis
Particle size distribution	
D90	9
D50	4.4
D10	1.7
Bulk Density (kg / m^3)	685

D. Carbon Inhibitors

Corrosion of steel in concrete structures are very dangerous and plays a significant role in affecting the service life of the concrete structures. Various methods have been developed with the intent of preventing the corrosion and to enhance the service life of the concrete. The methods include either coating to the concrete surface, coating to the reinforcement, cathodic protection, electrochemical methods, alternative reinforcement, or corrosion inhibitors mixed in concrete mix. Corrosion inhibitors can increase working life of the concrete through extending the initiation time of corrosion or reducing corrosion rate

E. Admixture

These days concrete is being used for wide varieties of purposes to make it suitable in different conditions. In these conditions ordinary concrete may fail to exhibit the required quality performance or durability. In such cases, admixture is used to modify the properties of ordinary concrete so as to make it more suitable for any situation. Admixture has a power to change the whole properties of the concrete hence proper amount and adequate admixture should be used in concrete according to the site condition and requirement. There are various types of admixture some of them are given below.

1) Set-Retarding Admixtures
2) Super plasticizers
3) Accelerating Admixtures
4) Air entraining concrete admixture
5) Damp-proofing Admixture
6) Grouting Admixture

II. METHODOLOGY

A. General

In this work various experiments on M60 grade concrete one with addition of micro silica and other with Alccofine has been conducted separately and been compared. Some basic test like compressive test, temperature effect & rate analysis of M60 grade concrete are also performed and then comparison is done. The comparison shows among Micro-Silica and Alccofine which is more effective and can give more strength being economical

B. Target Mean Strength

As per MORTH the target mean strength of specimen is greater than the specified characteristic compressive strength by at least the current margin. The current margin for a concrete mix shall be determined and the values shall be taken as 1.64 times the standard deviation of sample test results. The sample test is taken from the concrete mixer or batching plant. The current margin for the initial design mix shall be taken as given in the table below

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Table 2.1 Target Mean Strength For Mix Design

Concrete grade	current margin	target mean strength
M15	10	25
M20	10	30
M25	11	36
M30	12	42
M35	12	47
M40	12	52
M45	13	58
M50	13	63
M55	14	69
M60	14	74
M65	15	80
M70	15	85
M75	15	90
M80	15	95
M85	16	101
M90	16	106

Hence from the above table it clear that M60 concrete grade sample should attain target mean strength of 74mpa for the better result for this experimental work.

III. RESULTS AND DISCUSSION

A. Mix Proportion Comparison

In this work comparison between M60 grade concrete with Micro-silica and Alccofine has been done separately. For the preparation of M60 grade concrete sample, various materials are taken which are actually used in civil site in various mega projects these materials are given below in the table with their quantity in 1 cubic meter

Table 3.1 Mix Proportion Per Cubic Meter For Micro-Silica

Material	Mix Proportion (kg)	
	Concrete with Micro-silica	Concrete with Alccofine
Cement	255	250
GGBS	285	225
Micro Silica	30	-
Alccofine	-	25
20 mm	561.51	589.45
10 mm	516.51	589.45
M Sand	671.09	739.73
Water	159.6	145
Admixture	2.79	2
Corrosion inhibitor	3	3

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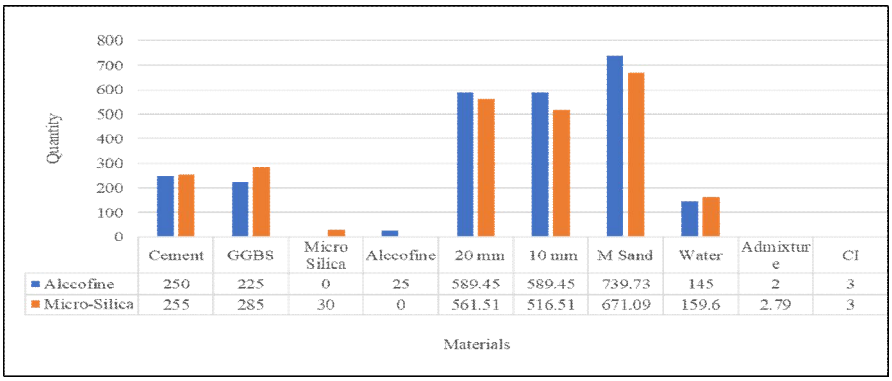

Fig.3.1 Graphical Comparison of Mix Proportion

B. Temperature and Slump Comparison

When water is mixed with concrete, hydration process takes place. Hydration process occur between cement and water. Due to this process heat is produce in the concrete which is known as heat of hydration. In this experiment both slump and temperature test has been performed by preparing M60 grade concrete with Micro-silica and Alccofine separately in every 30 minutes interval. The table for slump and temperature test is given below.

Table 3.2 Temperature and Slump Effect

SNO.	Duration	Temperature (0C)		Slump (mm)	
		Micro-Silica	Alccofine	Micro-Silica	Alccofine
1	Initial	27.8	27.6	190	180
2	½ hour	28.4	28.2	185	165
3	1 hour	28.8	28.6	140	144
4	1½ hour	29.6	29.4	125	120

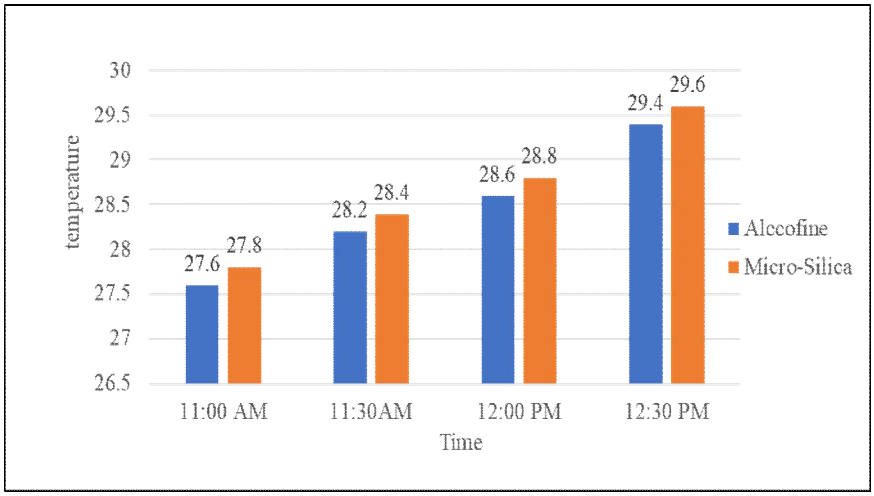

Fig 3.2 Graphical Comparison Of Temperature Test

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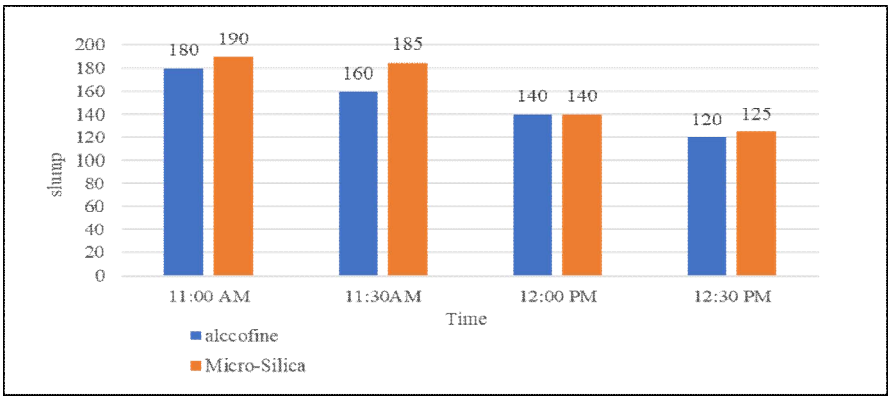

Fig 3.3 Graphical Comparison Of Slump Test

C. Compressive Test Results With Micro-Silica And Alccofine Separately

Compressive strength of concrete depends on many factors such as water-cement ratio, cement strength, quality of concrete material, quality control during production of concrete etc. For testing of compressive strength either cube or cylinder is used. In this experimental work cube of size 15cm x 15cm x 15cm is taken to carry out the compressive test and test result of seven and twenty-eight days are calculated

1) Seven days Compressive test results with Micro-Silica and Alccofine separately.

Table 3.2 Seven Days Compressive Test Table

SNO.	Cube added with	compressive strength N/mm2			final strength N/mm2
1	Micro-Silica	62.9	63.61	65.07	63.86
2	Alccofine	63.56	62.41	65.63	63.87

Fig 3.3 Comparison Of Seven Days Compressive Test Graphically

2) Twenty-Eight Days Compressive Test Results With Micro-Silica And Alccofine Separately

Table3.3 Twenty-Eight Days Compressive Test Table

SNO.	CUBE ADDED WITH	COMPRESSIVE STRENGTH N/MM2			FINAL STRENGTH N/MM2
1	MICRO-SILICA	77.47	76.3	77.19	76.98
2	ALCCOFINE	78.06	77.54	77.64	77.74

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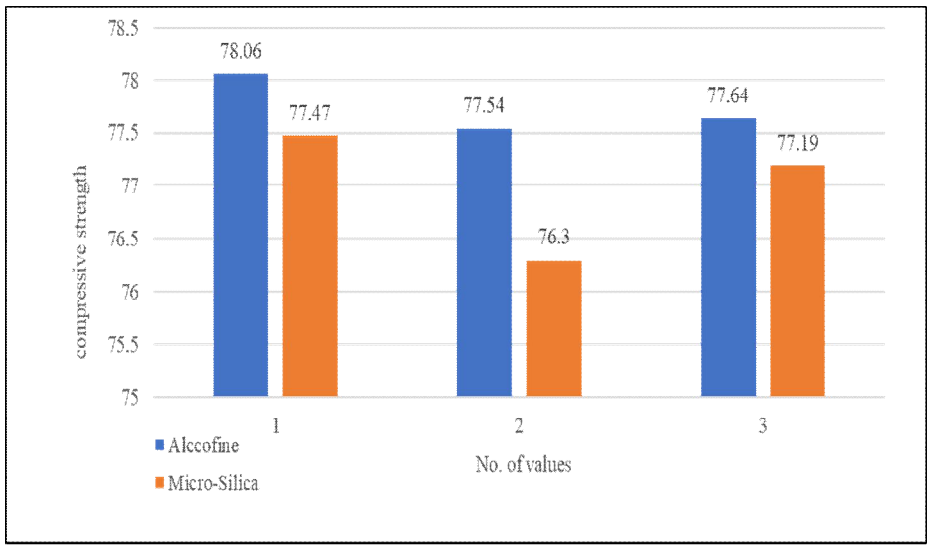

Fig 3.4 28 Days Compressive Test Comparison Graph

IV. CONCLUSIONS

A. It was observed that addition of Alccofine reduce the dosage of cement, GGBS, water in concrete mix

B. Presence of Alccofine in concrete lower down the formation of heat of hydration as compare to the concrete with micro silica

C. The sudden drop of slump of the concrete with Alccofine in first 30 min can affect the workability of concrete when the pouring is done with concrete pump or boom placer.

D. With the help of compressive test results, we found that presence of Alccofine in concrete gives more strength as compare to concrete with Micro-Silica

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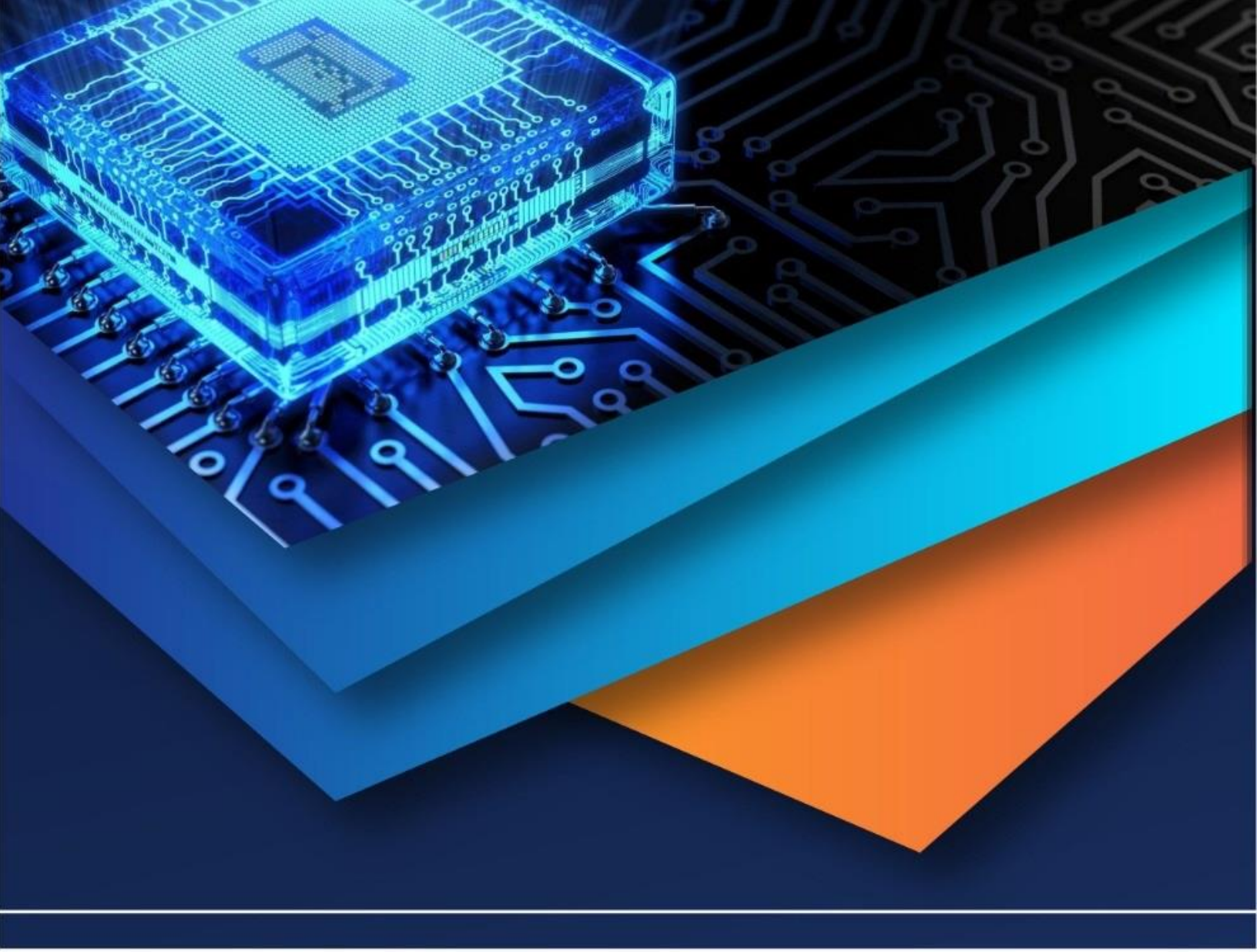

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