IJMTARC – VOLUME – V – ISSUE – 23, JULY-SEP, 2018 ISSN: 2320-1363

A STUDY OF HIGH PERFORMANCE CONCRETE BY USING ADMIXTURE LIKE METAKAOLIN, SLAG, SILICA FUME ON M80 GRADE CONCRETE

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ABSTRACT: High overall performance Concrete is the concrete meets the unique performance and necessities of uniformity that aren't to be received via traditional material, regular mixing, placing and curing practices. In this look at, a short evaluate on strength and sturdiness on M80 grade of concrete effects, a brand new composite material has been evolved and progressed Binders are advanced. Important governing elements for HPC (High Performance Concrete) are energy, long time durability and serviceability. As in keeping with Indian fashionable code IS: 456-2000 concrete of compressive energy ≥60Mpa.Concrete of grades M80 and M90 and so on.Are taken into consideration as High Performance Concrete (HPC). In this assignment mineral admixtures particularly Fly Ash, Silica Fume, Slag&Metakaolin contributed by numerous reputed industries are used.

In this mission work, a short evaluate offered on "A STUDY OF HIGH PERFORMANCE CONCRETE BY USING ADMIXTURE LIKE METAKAOLIN,SLAG,SILICA FUME ON M80 GRADE CONCRETE ".I actually have extensively utilized fantastic plasticizer namely VARAPLAST SP125 manufactured through "AKARSH SPECILATIES IN CHENNAI". I used those splendid plasticizers a good way to attain decrease water-cement ratio and to gain proper workability while we move for High Strength Concrete consisting of M80. I even have compared the combinations of various chances of admixtures in M80. I offered the mixture represented these consequences within the form of BAR CHARTS and GRAPHS. The electricity checks consist of compressive, split tube tensile and flexural checks for cubes, cylinders and beams. And durability checks include Acid-Alkali attack checks and Rapid permeability chloride exams have been conducted and the test results were provided in graphs and bar charts.

INTRODUCTION

GENERAL: Concrete is a strong& durable material. The most popular material Reinforced concrete is used though out the world for construction. After all experiments and researches respect to workability, strength and durability of concrete is increased very much and gives a special performance is called as "High Performance Concrete". It is a range of materials combining of products beyond the conventional mix concrete and construction methods.

HISTORICAL BACKGROUND: However the concrete of high strength is consider for innovative material which is developing in USA, having the compressive strength 34MPa.62mpa concrete was being developed in 1970's. the reactive concrete is also having the compressive strength of 250mpa.It is completely based on pozzolanic materials.

HIGH PERFORMANCE CONCRETE: High Performance Concrete (HPC) is to give performance characteristics for set of materials used and exposure conditions depending on the requirement of cost, life period and durability. The factor for durability of concrete is >80.

NEED OF HIGH PERFORMANCE CONCRETE

- To reduce the column sizes and increasing available space by constructing of high-rise buildings
- To construct long-term bridges and to increases the durability of bridge decks.
- For satisfying the needs of applications like durability, modules of elasticity, flexural strength.

TABLE 1.1: PERFORMANCE CHARACTERSTICS OF HIGH PERFORMANCE CONCRETE

PERFORMANCE CHARACTERITICS	REQUIREMENTS
Flow ability and work ability	Easier
Bleeding	None or negligible
Ultimate strength- 90days+	Higher
Durability	Very high especially after 3months
Cost	Lower-Initial cost of HPC is higher due to extra over head in quality control and processing, the benefit of extended service life, among many other benefits, exceeds by far the high initial cost.

APPLICATION OF HIGH PERFORMANCE CONCRETE

Some specific applications of high Performance concrete in various situations have been discussed below.

BUILDINGS: The most common application of high strength concrete is in multi storied buildings.For concrete buildings of ordinary low strength concrete, the potential number of storeys is limited by the large columns and shear walls. Thenumber of storey's is limited by the large columns and shear walls. The number of storey can Be increased by using high strength concrete in the construction of these columns And shear walls.

The most economical columns and shear walls are the ones with the smallest cross sectional areas and the minimum percentage of steel. Thus, the use of high strength concrete, together with high yield strength steel, seems to be very attractive for the economical point of view. The most economical columns and shear walls are the ones with the smallest cross sectional areas and the minimum percentage of steel.

Thus, the use of high strength concrete, together with high yield strength steel, seems to be very attractive for the economical point of view.Since 1972, more than 20 buildings in Chicago have been constructed with columns having design compressive strength of 62Mpa. Other applications have been reported in Toronto, New York, Houston, Minneapolis and Melbourne, Australia.

PERFORMANCE CONCRETE

- **Finish ability and slump**
- **Lack of bleed water**
- **Trial mixes**
- **Preconstruction meeting**
- **Testing**
- **Plastic shrinkage and mandatory curing—**

LITERATURE REVIEW

GENERAL

Many works have been done to explore the benefits of using pozzolanic materials in making andenhancing the properties of concrete.

REVIEW OF LITERATURE

1)M.H.Shehataand **M.D.A. Thomas,** studied theternary cementitious blends of fly ash, silica fume and Portland cement, gives the important advantages over binary blends and even greater increases over plain Portland cement.

2) SandorPopovics and**Jan Bijen**studied thesystemsof Portland cement-fly ash – silica fume in concrete andconcluded several beneficial effects to addition of silica fume to the fly ash cement mortar in the form of strength, workability and ultra sonic velocity test results.

3)C.S. Poonand**L. Lam, Y.L. Wong,** in their studied entitled Effect ofsilica fume andfly ash onfracture behaviorsand compressive of concrete had concluded that increase instrength properties of concrete by adding different percentages of silica fume andfly ash.

EXPERIMENTAL PROGRAMME

PURPOSE: In this project I planned to conduct the lab investigation using mineral and chemical admixtures in different proportions, grade of concrete is$\mathbf{M_{80}}$

The tests were conducted for the concrete are as follows:

- Workability test
- Compressive strength test
- Split tensile strength test
- Fluxral strength test
- Acid attack test
- Alkaline attack test

TEST PROGRAM: The cubes are having the dimensions 150mm x 150mm x 150mm of standard sizes. These are constant for all the specimens. The Cubes are tested in compression testing machine which is having maximum capacity of 400 tons.

CEMENT: Cement is binding material which is the combination of raw materials called calcareous and argillaceous materials. Zuari-53 grade ordinary Portland cement conforming to IS: 12269 were used in concrete

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TABLE – 3.1 PHYSICAL PROPERTIES OF ZUARI 53 GRADE CEMENT

S.No.	Properties	Test results	IS: 12269-1987
1.	Normal consistency	0.32	
2.	Initial setting time	60min	Minimum of 30min
3.	Final setting time	320min	Maximumof600min
4.	Specific gravity	3.15	
5.	Compressive strength		
	(a) 3days strength	29.4Mpa	Minimum of 27Mpa
	(b) 7days strength	44.8Mpa	Minimum of 40Mpa
	(c) 28days strength	56.53Mpa	Minimum of 53Mpa

AGGREGATES

For coarse aggregate, crushed granite rock of 20mm maximum size was used. For fine aggregate Natural sand from Swarnamukhi River in Srikalahasti was used. The individual aggregates are blend to obtain the desired combined grading.

TABLE – 3.2 PHYSICAL PROPERTIES OF AGGREGATE

Specific Gravity of coarse aggregate	2.76
Specific Gravity of fine aggregate	2.60

TABLE – 3.3 GRADING OF FINE AND COARSE AGGREGATE

SIEVE SIZE(MM)	20MM	NATURAL SAND
40	100.00	100.00
20	90.20	100.00
10	7.60	100.00
4.75	1.20	99.50
2.36	___	97.00
1.18	___	81.50
0.6	___	59.00
0.3	___	4.05
0.15	___	2.00
0.075	___	1.07

WATER: Potable water is used for curing and mixing of concrete cubes.Concrete mixture water should be as clean as possible and there should contain as much substances such as chloride, sulphate, acid, sugar, organic materials, industrial waste, oil, clay and silt which may be harmful.

METAKAOLIN

Considerable research has been done on activated ordinary clay and kaolinitic clay. These un purified materials have often been called as "metakaolin". Such a product white or cream in color, purified, thermally activated is called s "high reactive metakaolin".High reactive metakaolin by trade name "METACEM" is being manufactured in India by "SPECIALITY MINERALS DIVISION" in BARODA.

Figure 3.3 METAKAOLIN

Metakaolin that we have used in this project work was contributed by "AKARSHA SPECIALITIES IN CHENNAI"

CALCINED CLAY – HIMACEM is a High Reactivity Metakaolin (HRM), which is manufactured by the high temperature treatment of specially selected kaolin under controlled conditions. It is a white mineral admixture, having very good pozzolanic properties. It reacts with free lime produced during the hydration of cement to form additional cementations products.

a) HIGH REACTIVE METAKAOLIN AS A VALUE ADDED CONCRETE ADMIXTURE

High Reactive Metakaolin (HRM) is a value added concrete admixture and is being increasingly used in the developed countries in place of silica fume.HRM can be used as a highly effective pozzolanic admixture to Provide high compressive strengths.Reduce permeability and penetration of ions

300 mesh w/w % (Max)	:	0.1.
-2 micron w/w % (Min)	:	60.0.
Moisture w/w % (Max)	:	0.5-1.0.
Metakaolin content %(Min):		98.0.
Reactivity with lime (%)	:	95.0-97.0

TYPICAL ANALYSIS

PHYSICAL:-

Appearance	:	Off-White.
PH (10% solids)	:	4.0 – 5.5
Bulk density (kg/lit)	:	0.4-0.5.
Specific surface area m^2/kg	:	10-12.
Specific gravity	:	2.6.

CHEMICAL (Mass %):-

SiO_2	:	52.0.
Al_2O_3	:	46.0
Fe_2O_3(Max)	:	0.60.
TiO_2 (Max)	:	0.65
CaO (Max)	:	0.09
MgO (Max)	:	0.03
Na_2O (Max)	:	0.10.
K_2O (Max)	:	0.03
Loss on ignition		0.50

4) GROUND GRANULATED BLAST FURNACE SLAG (GGBS)

Ground-granulated blast-furnace slag (GGBS) is obtained by quenching molten iron slag (a byproduct of iron and steel-making) from a blast furnace in water or steam, to produce a glassy, granular product that is then dried and ground into a fine powder. GGBS cement can be added to concrete in the concrete manufacturer's batching plant, along with Portland cement, aggregates and water. The normal ratios of aggregates and water to cementitious material in the mix remain unchanged. GGBS is used as a direct replacement for Portland cement, on a one-to-one basis by weight.

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Figure 3.4 ground granulated blast furnace slag

MIX DESIGN

4.1 MIX DESIGN FOR PRESENT INVESTIGATION

In the present work the Indian, Standard Method (Is METHOD) has been used to get propositions for high strength concretehe concrete mix design for M80 and M90 were carried out according to Indian standard recommendation method is 10262-2009.

4.2 MIX DESIGN FOR M80:

STIPULATIONS FOR PROORTIONIN:

Grade designation	=	M80
Type of cement	=	OPC 53 grade
Mineral admixture	=	Fly ash
Maximum nominal size aggregate	=	12.5mm
Maximum water content	=	0.4mm
Workability	=	100mm (slump)
Exposure condition	=	Severe (reinforced concret
Degree of supervision	=	Good
Type of aggregate	=	Crushedangular aggregate
Chemical admixture	=	Varaplast SP123

TEST DATA FOR MATERIAL:

Cement used	=	OPC 53
Specific gravity of cement	=	3.15
Specific gravity of fly ash	=	2.2
Chemical admixture	=	Super plasticizer
Specific gravity		
Coarse aggregate	=	2.74
Fine aggregate	=	2.60
Water absorption		
Coarse aggregate	=	0.5 percent
Fine aggregate	=	1.0 percent
Free moisture in		
Coarse aggregate	=	Nil
Fine aggregate	=	Nil

DESIGN:-

Target strength for mix proportion

f'_{ck} $= f_{ck}+1.65s$

$=80+1.65X\ 5$

$=88.25\ N/mm^2$

SELECTION OF WATER – CONTENT RATIO:

From table 5 of Is 456 -2000 maximum

w/c =0.4

Adopt =0.35

SELECTION OF WATER CONTENT:

Maximum water content for 12.5 mm aggregate

=202.5lit

Estimate water content for 100mm slump

$= 202.5+\frac{6}{100} X\ 202.5 =$ 215 lit

As super plasticizer is used the water content reduced up to 30 percent.

Based on trials with super plasticizer water content reduction of 29 percent has been achieved.

Hence arrived water content

=215 X 0.71

=153 lit

CALCULATION OF CEMENT AND FLY ASH CONTENT:

Water cement ratio = 0.35

Cementitious material content =153/0.35

= 437.14 kg/m3

Increase cementitious material content

= 437.14 x 1.10

= 480.85 Kg

Water content = 153 lit

Water – cement ratio = 153/480.85

= 0.31

Fly – ash at 20% of total cementitious material

=480.85 x 20%

=96.17 Kg

Cement =480.85-96.17

=384.68 Kg/m3

Fly ash being utilized =96.17 Kg.

4.3 PROPORTION OF VOLUME OF COARSE AGGREGATE AND FINE AGGREGATE CONTENT:

Volume of coarse aggregate corresponding to 12.5mm size and fine aggregate zone 4 for water – cement ration 0.5 = 0.54

Water – cement ratio = 0.31

As the w/c is lower by 0.10 the proportion of volume of coarse aggregate is decreased by 0.02.

Therefore for w/c 0.31 the

Volume of coarse aggregate = 0.54+0.05

= 0.59

Volume of fine aggregate = 1 – 0.59

= 0.41

MIX CALCULATION:

a. Volume of concrete = $1m^3$

b. Volume of cement

$$=\frac{Mass\ of\ cement}{Specific\ gravity\ of\ cement} X \frac{1}{1000}$$

$= (384.68/3.15)\times(1/1000)$

$= 0.122\ m^3$

c. Volume of fly ash

$$=\frac{Mass\ of\ fly\ ash}{Specific\ gravity\ of\ fly\ ash} X \frac{1}{1000}$$

$= (96.17/2.2)\times(1/1000)$

$= 0.043\ m^3$

d. Volume of chemical admixture

$$=\frac{Mass\ of\ admixture}{Specific\ gravity\ of\ admixture} X \frac{1}{1000}$$

$$= \frac{12.13}{1.08} X \frac{1}{1000}$$

$= 0.011\ m^3$

e. Volume of water $= \frac{153}{1} X \frac{1}{1000}$

$= 0.153$

Volume of all in aggregate =a – (b+c+d+e)

=1 – 0.328

=0.672

Mass of coarse aggregate =f ×volume of coarse aggregate×S.G ×1000

= 0.59 ×0.672 × 2.74 ×1000

= 1086.35Kg

Mass of fine aggregate =f ×volume of coarse aggregate×S.G ×1000

=0.41 × 0.672× 2.60 ×1000

=716.35Kg

MIX PROPORTION:

Cement =384.68 kg/m^3
Fly ash =96.17 kg/m^3
Water =153kg/m^3
Fine aggregate =716.35 kg/ m^3
Coarse aggregate = 1086.35 kg/m^3
W/C =0.31

TABLE 4.1 MIX PROPORTION FOR M80 CONCRTE

Cement	Fine aggregate	Coarse aggregate	Water
480.85	716.35	1086.35	153
1	1.489	2.26	0.31

4.4 MIXING, CASTING AND CURING

Mixing of concrete was done by using hand. All the ingredients of concrete were weighed and batched according to the mix proportions. The order of mixing the ingredients of concrete was first fine aggregates, cement, coarse aggregate and finally water with admixture or without admixture. The materials must be thoroughly mixed to obtain a good mix. After getting a mix, the moulds must be taken and apply grease to the inner surface of the mould for getting cubes easily. Concrete is poured in each mould by three layers. Each layer is to be tamped 25 times by using tampering rod, and the finally keep the mould by three layers. Each layer is to be tamped 25 times by using tampering rod, and the finally keep the mould on vibrator to get a void less cube. After casting the moulds they are to be de – molding after 24 hours.

The curing must be done immediately after removing the moulds. Normal immersion curing is enough for the cubes.

4.5 LOADING ARRANGEMENT

The cubes are tested by using compression testing machine for 7 days and 28 days. The maximum capacity of the testing machine is 200tons. The load was transferred from jack, through a steel circular section.

For measuring ultimate strength load dial gauges of least count 100 kgs were placed behinds the compression testing machine.

TEST RESULTS AND DISUSSIONS

5.1 WORKABILITY

The concrete which exhibits very little internal friction b/w particle and particle which overcomes the frictional resistance offered by the formwork surface or reinforcement contained in the concrete.

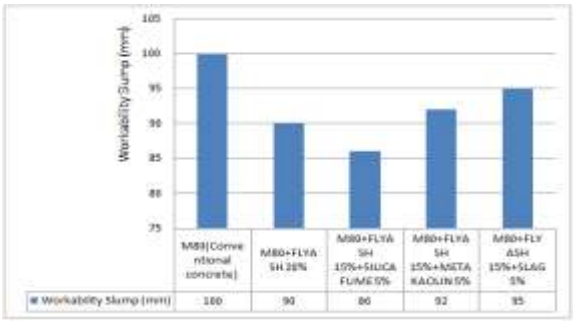
Figure 5.1 SLUMP CONE

It is the most common method for measuring the workability of freshly mixed concrete. It can be performed both in lab and at site. Uniformity of the concrete regarding workability and quality aspects can be assessed from batch to batch by observing the nature in which the concrete slumps. It is not very suitable for very wet or very dry concreteThemould is cleaned and freed from any surface moistures and then the concrete is placed in three layers. Each layer is tamped 25 times with a standard tamping rod (16 mm dia, 0.6 meter length). Immediately after filling, the cone is slowly lifted and the concrete is allowed to subside. The decrease in the height of the center of the slumped concrete is called slump and is measured to the nearest 5mm.

TABLE: 5.1 TEST RESULTS FOR WORKABILITY

S.No	Grade of concrete	Workability Slump (mm)
1.	M_{80}(Conventional concrete)	100
2.	M_{80}+FLYASH 20%	90
3.	M_{80}+FLYASH 15%+SILICA FUME 5%	86
4.	M_{80}+FLYASH 15%+METAKAOLIN5%	92
5.	M80+FLY ASH 15%+SLAG 5%	95

IJMTARC – VOLUME – V – ISSUE – 23, JULY-SEP, 2018 ISSN: 2320-1363



GRAPH:5.1 TEST RESULTS FOR WORKABILITY

5.2 COMPRESSIVE STRENGTH

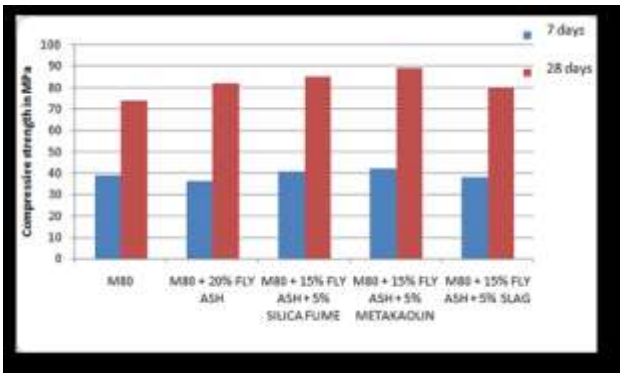
Compression is the test commonly conducted for concrete, so that we can obtain the quality properties. The size of the cube specimen 15cm X 15cm X 15cm was cast to test various concrete mixtures for compressive strength. After moulding, kept for curing for 7 days and 28 days the compressive strength was conducted. The water and grit on the cubes was removed before testing the cubes. The test was carried as per IS: 516-1959.

FIGURE: 5.2 COMPRESSION TESTING MACHINE

This concrete is poured in the mould and tempered properly so as not to have any voids. After 24 hours these moulds are removed and test specimens are put in water for curing. The top surface of these specimen should be made even and smooth. This is done by putting cement paste and spreading smoothly on whole area of specimen. These specimens are tested by compression testing machine after 7 days curing or 28 days curing. Load should be applied gradually at the rate of 140 kg/cm2 per minute till the Specimens fails. Load at the failure divided by area of specimen gives the compressive strength of concrete.

TABLE:5.2compressive Strength For 7 Days And 28 Days

S.No	Grade of concrete	Compressive strength Of 7 days (Mpa)	Compressive Strength of 28 days (Mpa)
1.	M_{80}	39.00	74.00
2.	M_{80}+FLYASH 20%	36.40	82.00
3.	M_{80}+FLYASH 15%+SILICA FUME 5%	41.00	85.30
4.	M_{80}+FLYASH15%+METAKAOLIN 5%	42.00	89.30
5.	M80+FLY ASH 15%+SLAG 5%	38.2	79.6



GRAPH: 5.2COMPRESSIVE STRENGTH FOR 7 DAYS AND 28 DAYS

5.3 CYLINDER SPILITING TENSION TEST:

This is also sometimes referred as "Brazilian test". This test is carried out by placing a cylindrical specimen horizontally between the loading surfaces of a compression testing machine and load is applied until failure of the cylinder along the vertical diameter. When load is applied along the generatix, an element on the vertical diameter of the cylinder is subjected to a vertical compressive stress

FIGURE 5.3: SPLIT TUBE TENSILE TEST APPARATUS

$$F_t = \frac{2p}{\pi dl}$$

Where,
P = maximum tensile load
L = length of the cylinder
d = diameter of the cylinder

The cylindrical mould shall be of 150 mm diameter and 300 mm height conforming to IS: 10086-1982.testing machine should be able to apply the load continuously andwithout shock. it should be able to apply loads at a constant rate within the range 0.7 to 1.4 MPa/min (1.2 to 2.4 MPa/min based on IS 5816 1999) splitting tensile stress until the specimen fails.Record the maximum applied load indicated by the testing machine at failure. Note the type of failure and appearance of fracture.

TABLE: 5.3 TENSILE TES3TS FOR 7 DAYS AND 28 DAYS

S.No	Grade of concrete	Split- tensile strength Of 7 days (Mpa)	Split- tensile Strength of 28 days (Mpa)
1.	M_{80}	2.79	6.2
2.	M_{80}+FLYASH 20%	2.7	6.0
3.	M_{80}+FLYASH 15%+SILICA FUME 5%	2.655	5.9
4.	M_{80}+FLYASH15%+METAKAOLIN5%	2.835	6.3
5.	M80+FLY ASH 15%+SLAG 5%	2.745	6.1

GRAPH:5.6 COMPRESSION STRENGTH OF CUBES AFTER 28DAYS OF ACID CURING

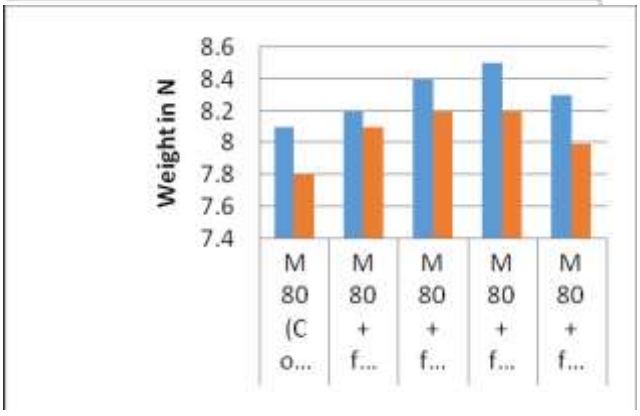
5.6ALKALINE ATTACK TEST:

The resistance of concrete mixtures in alkaline attack test will be determined by the concrete cubes immersed in alkaline water having 5% of sodium hydroxide (NaOH) by weight of water. The concrete cubes which were cured for 28 days in water andremoved from the curing tank allowed drying for 1day.

FIGURE 5.6: ALKALINE ATTACK TESTOF CONCRETE CUBES

TABLE: 5.6%LOSS OF WEIGHT REDUCTION OF CUBES AFTER 28DAYS ACID CURING:

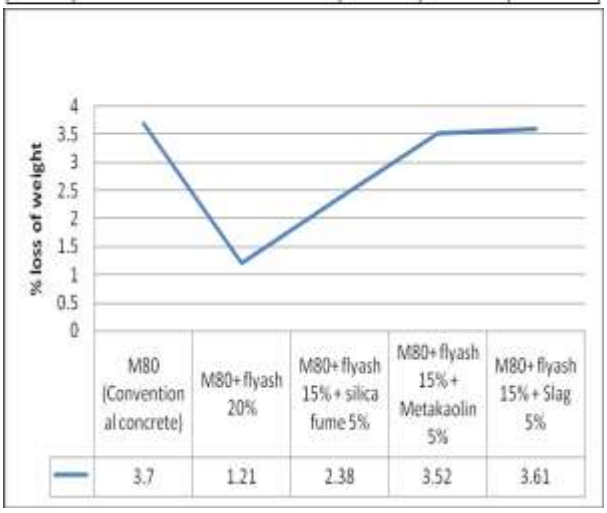
S.NO	GRADE OF CONCRETE	INITIAL WEIGHT	FINAL WEIGHT	% LOSS IN WEIGHT
1.	M80 (CONVENTIONAL CONCRETE)	8.1	7.9	2.469
2.	M80+ FLYASH 20%	8.2	8.0	2.439
3.	M80+ FLYASH 15% + SILICA FUME 5%	8.4	8.1	3.571
4.	M80+ FLYASH 15% + METAKAOLIN 5%	8.5	8.3	2.352
5.	M80+ FLYASH 15% + SLAG 5%	8.3	8.1	2.409



GRAPH 5.7: % LOSS OFCOMPRESSIVE STRENGTH REDUCTION OF CUBES AFTER 28DAYS

TABLE 5.6:%LOSS OF WEIGHT REDUCTION OF CUBES AFTER 28DAYS ACID CURING:

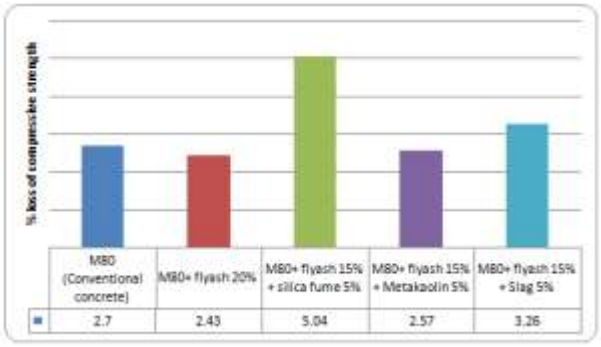
S.NO	GRADE OF CONCRETE	INITIAL WEIGHT	FINAL WEIGHT	% LOSS IN WEIGHT
1.	M80 (Conventional concrete)	8.1	7.8	3.70
2.	M80+ flyash 20%	8.2	8.1	1.21
3.	M80+ flyash 15% + silica fume 5%	8.4	8.2	2.38
4.	M80+ flyash 15% + Metakaolin 5%	8.5	8.2	3.52
5.	M80+ flyash 15% + Slag 5%	8.3	8.0	3.61



GRAPH: 5.8 % LOSS OFCOMPRESSIVE STRENGTH REDUCTION OF CUBES AFTER 28 DAYS

TABLE: 5.7%LOSS OF COMPRESSIVE STRENGTH REDUCTION OF CUBES AFTER 28 DAYS

S.No.	GRADE OF CONCRETE	COMPRESSIVE STRENGTH WITH WATER CURING	COMPRESSIVE STRENGTH AFTER ALKALINE ATTACK	% LOSS IN COMPRESSIVE STRENGTH
1.	M80 (Conventional concrete)	74	72	2.70
2.	M80+ flyash 20%	82	80	2.43
3.	M80+ flyash 15% + silica fume 5%	85.3	81	5.04
4.	M80+ flyash 15% + Metakaolin 5%	89.3	87	2.57
5.	M80+ flyash 15% + Slag 5%	79.6	77	3.26



GRAPH: 5.9 %LOSS OF COMPRESSIVE STRENGTH REDUCTION OF CUBES AFTER 28DAYS ACID CURING

CONCLUSIONS:

- In high performance concrete mix design the water cement ratio is adopted low.It is necessary to maintain super plasticizers for required workability. When the percentage of mineral admixtures in the mix increases super plasticizer percentage also increases for obtaining of required strength.
- In case of different combinationsof percentage replacement of mineral admixtures gives the maximum compressive strength for M80 grade concrete in 89.3 Mpa with replacement of cement by15% fly ash and 5% MetakaolinMineral admixtures such as Fly ash, micro silica, metkaolin& Slag also contribute effectively for achieving high strength.
- The scope of using high performance concrete in our constructional activities lies large, viz., precast, prestressed bridges, multi-storied buildings, bridges and structures on coastal areas and like. To affect this change, we will have to revive the designing to structures by encouraging use of high strength concrete.

- As soon as micro crack appears, sudden failure is observed in high strength concrete cubes.

SUGGESTIONS FOR THE FUTURE WORK

- This investigation is also carried for different W/C ratios for different mineral and chemical admixtures, also for different concrete grades.
- Flyash andMetakaoin combinations are proved to be the most effective among all the mineral admixtures as it contributes to achieve very high compressive strength.
- Silica fume and flyash combination proves to be the most effective among all the mineral admixtures as it contributes to achieve high durability even in severe exposure condition.
- It is suggest that the study of permeability of concrete for the estimation of concrete durability may be extended.

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