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

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ABSTRACT: High performance Concrete is the concrete meets the special performance and requirements of uniformity that are not to be obtained by conventional material, normal mixing, placing and curing practices. In this study, a brief review on strength and durability on M80 grade of concrete results, a new composite material has been developed and improved Binders are evolved. Important governing factors for HPC (High Performance Concrete) are strength, long term durability and serviceability. As per Indian standard code IS: 456-2000 concrete of compressive strength ≥60Mpa.concrete of grades M80 and M90 etc. are considered as High Performance Concrete (HPC). In this project mineral admixtures namely Fly Ash, Silica Fume, Slag& Metakaolin contributed by various reputed industries are used. The strength tests include compressive, split tube tensile and flexural tests for cubes, cylinders and beams. And durability tests include Acid-Alkali attack tests and Rapid permeability chloride tests were conducted and the test results were presented in graphs and bar charts.

Key Words : Metakoline, Silica Fume , compressive Strength , split tube tensile Strength and flexural Strength

1.INTRODUCTION:

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. 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 (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

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durability of concrete is >80. As Henry G. Russell, who is consulting engineer and former chairman of the American Concrete Institute's high performance concrete committee, "All high- strength concrete is high performance concrete, but not all high performance concrete is high-strength concrete" High Performance Concrete (HPC) is a product which includes materials with different special properties compared to the conventional concrete and construction methods.

2. EXPERIMENTAL PROGRAMME MATERIALS USED

In the present investigation the following materials were used: Zuari-53 grade cement conforming to IS: 12269 – 1987.¬ Fine aggregate and coarse aggregate conforming to IS: 383 – 1970.¬ Admixtures.¬ i) CEMENT 3 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

TABLE – 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	Maximumof 600min
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

ii) 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 – PHYSICAL PROPERTIES OF AGGREGATE

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

TABLE – 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

iii) WATER

Potable water is used for curing and mixing of concrete cubes.

iv) ADMIXTURES

The addition of chemicals to concrete at the stage of mixing for modification of the properties of the mix is called admixtures. Admixtures are chemicals which are added to

concrete at the mixing stage to modify some of the properties of the mix. Admixtures should never be regarded as a substitute for good mix design, good workmanship, or use of good materials.

1. Chemical admixtures

2. Mineral admixtures

v) CHEMICAL ADMIXTURE

The small amount of Chemical admixtures are added to concrete for entertainment of air, water reduction or cement content, setting time controlling. Seven types of chemical admixtures are specified in ASTM 494, and AASHTOM 194, depending on their purpose or purposes in PPC. General and Physical requirements for each type admixtures which were used are including in specifications.

1. Air – Entrainment

2. Water – Reducing

3. Set – Retarding

4. Accelerating

5. Super Plasticizers

The chemical admixture which we used in this present project is polycarboxylic ether

VI) FLY ASH

The combustion of coal by using flue gases, results the collection of electrostatic precipitator. The most widely used mineral admixture is fly ash over the world. Extensive research has given the benefits that can be achieved by utilization of fly ash. At present all

over the world high volume of fly ash concrete is very much preferred. The generation of quality of fly ash from various plants to more extent & not to be use. Fly ash is the most widely used mineral admixture all over the world. The quality of fly ash generated from different plants vary from one another to a large extent and hence they are not ready to be used in concrete further processing is necessarily done.

vii) SILICA FUME

Silica fume, also referred as micro silica or condensed silica flume, is another material that is used as artificial mineral admixtures Silica fume as an admixture has opened a new advancement in concrete technology. The usage of super plasticizer with silica fume has been the backbone of modern high performance concrete. It should be noted that silica fume by itself, doesn't contribute to strength. However it produces the property of strength being fine pozzolanic material. Silica fume helps in reduction of water becomes possible in presence of high dosage of super plasticizer and dense packing of cement paste. Pierre-Claude Aiticn and Adam Neville in one of their papers "High Performance Concrete" states that "strengths in the range of 60 to 80 MPa have been achieved, as silica fume simplifies the production of high performance concrete and makes it easier to achieve compressive strength in the range of 60 to 90 MPa. Silica fume that we have used in this project work was contributed by "AKARSHA SPECIALITIES in CHENNAI". Its properties are mentioned below. Micro silica is initially produced as an ultra fine dandified powder.

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Size of particle lies between 0.1 and 0.2 micron.

ix). 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 metakailin by trade name "METACEM" is being manufactured in India by SPECIALITY MINERALS DIVISION" in BARODA. Metakaolin that we have used in this project work was contributed bym "AKARSHA SPECIALITIES IN CHENNAI"

3. PRINCIPLE MECHANISMS:

1.The very fine particles of micro silica have the possibility to fill the microscopic voids between particles, creating a less permeable concrete structure. The manufacturing process ensures the optimization of particle size and distribution.

2.The pozzolanic reaction occurring when the free calcium hydroxide liberated in the cement hydration process reacts with micro silica to produce additional calcium silicate hydrate (crystalline formations).

3.The proper size of a particle reduces concrete bleeding also helps improves bond at the aggregate interface with cement paste.

MICRO SILICA FOR HIGH STRENGTHS CONCRETE

Micro silica increases concrete strengths producing financial benefits to builders, developers and property owners. Columns and wall thickness are reduced providing cost saving and improved construction schedules. The internal cohesiveness of micro silica ensures a smooth formwork finish.

MICRO SILICA FOR COMMERCIAL AND INDUSTIAL FLOORS

Micro silica produces a tough durable concrete ideally suited to meet the high performance demands of today's industrial floors. Micro silica will provide optimal concrete bleed for limiting cracking, settlement.

MICRO SILICA FOR SHOTCRETE

The use of micro silica in shot Crete eliminates expensive formwork and reduces construction time.

MICRO SILICA FOR CHEMICAL RESISTANT CONCRETE

Micro silica concrete is resistant to many industrial chemicals. It has excellent sulphate resistance and reduces the effect of alkali aggregate reactivity.

MICRO SILICA FOR MARINE CONCRETE

Micro silica produces a marine concrete, which has an extremely low chloride diffusion coefficient and high resistivity. It is a very effective concrete for marine environments as it efficiently resists the corrosion of steel.

MICRO SILICA FOR WATERPROOF CONCRETE

The decrease in permeability is due to pozzolanic reactivity refining the cement

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paste pore structure. The use of membranes or other waterproofing treatments below or above ground structures is minimized or even can be avoided. Any waterproofing system must meet all serviceability criteria.

4. TEST RESULTS AND DISUSSIONS

i) 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.

TABLE:TESTRESULTSFOR 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%+METAKAOLIN 5%	92

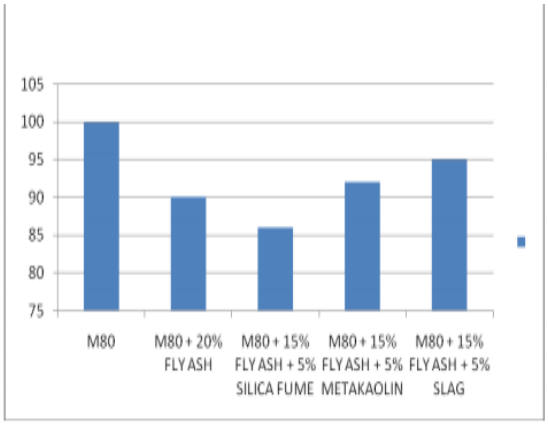
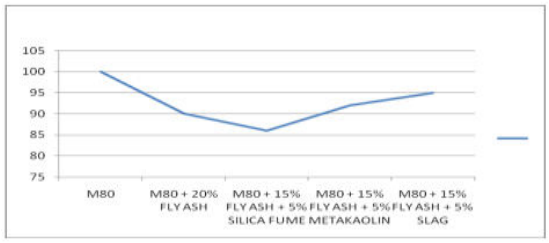


FIGURE: TEST RESULTS FOR WORKABILITY



TEST RESULTS FOR WORKABILITY

ii) 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 molding, 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.

COMPRESSION TESTING MACHINE

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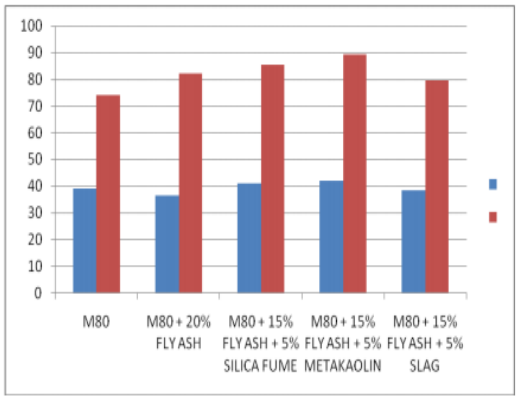
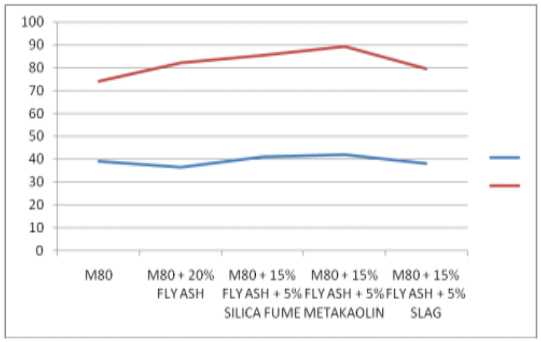
COMPRESSIVE STRENGTH FOR 7 DAYS AND 28 DAYS

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



COMPRESSIVE STRENGTH FOR 7 DAYS AND 28 DAYS



COMPRESSIVE STRENGTH FOR 7 DAYS AND 28 DAYS

iii) 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

$$Ft = 2P/ (¶ d l)$$

Where P= maximum tensile load

l = length of the cylinder

d = diameter of the cylinder

PLIT TUBE TENSILE TEST APPARATUS

TENSILE TESTS 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}+FLYASH 15%+METAKAOLIN5%	2.835	6.3
5.	M80+FLY ASH 15%+SLAG 5%	2.745	6.1

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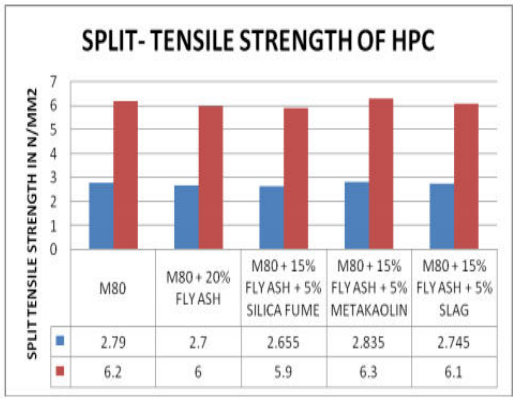
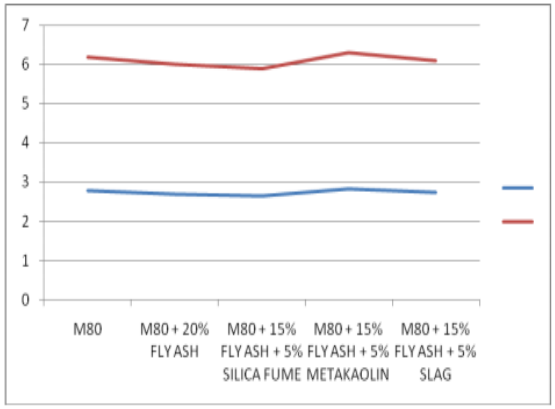


FIGURE: TENSILE TESTS FOR 7 DAYS AND 28 DAYS



IV) FLEXURAL STRENGTH TEST:

Prismatic specimens 100×100×500 mm were tested according to IS: 516(1959). The results for flexural strength of prisms for 7days and 28days are given in table.A primary concern in designing concrete for use in highway applications is the flexural strength of concrete. Its knowledge is useful in the design of pavement slabs and airfield runway as flexural tension is critacle in these cases. The flexural strength or the modulus of rupture of concrete is an indierect measure of the tensile strength. The value of modulus of rupture depends upon the dimensions of the beam and above all on the arrangement of loading. The flexural strength of the specimen is expressed as the modulus of rupture fb, which if 'a' equals the distance between line of fracture and the near support, measured on the centre line of the tensile side of the specimen, in cm, is calculated to the nearest 0.0005 MPa as follows:

$$f_b = \frac{p \times l}{b \times d^2}$$

when 'a' is greater than 20.0 cm for 15.0 cm specimen, or

$$f_b = \frac{3p \times a}{b \times d^2}$$

b×d

FLEXURAL STRENGTH BY ONE-POINT METHOD

FLEXURAL TEST FOR 7 DAYS AND 28 DAYS

S.No	Grade of concrete	Flexural strength Of 7 days (Mpa)	Flexural Strength of 28 days (Mpa)
1.	M_{80}	2.745	6.1
2.	M_{80}+FLYASH 20%	2.61	5.8
3.	M_{80}+FLYASH 15%+SILICA FUME 5%	2.655	5.9
4.	M_{80}+FLYASH 15%+METAKAOLIN 5%	2.81	6.26
5.	M80+FLY ASH 15%+SLAG 5%	2.565	5.7

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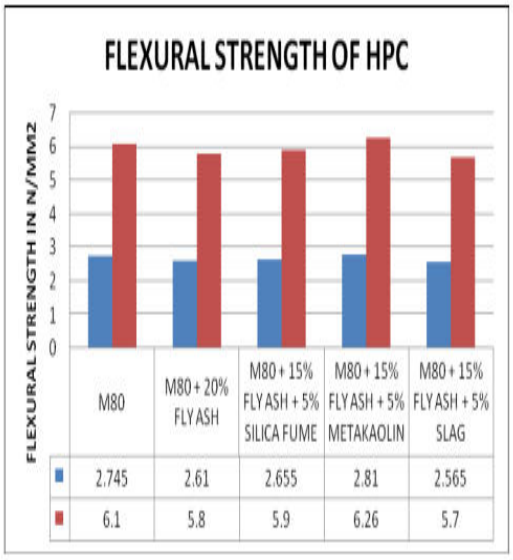
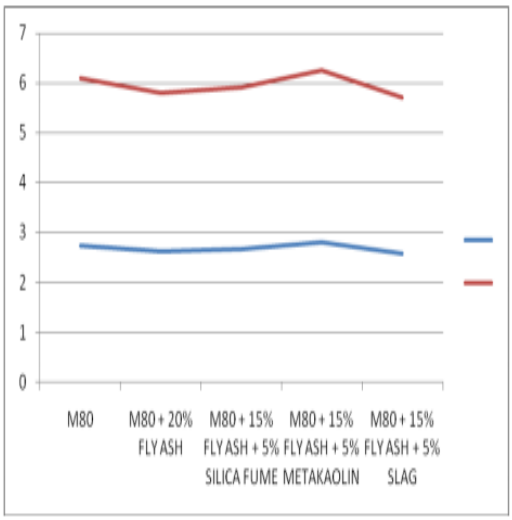


FLEXURAL TEST FOR 7 DAYS AND 28 DAYS



FLEXURAL TEST FOR 7 DAYS AND 28 DAYS

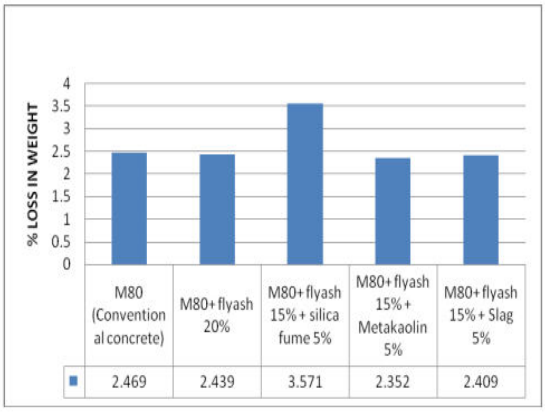
V) ACID ATTACK TEST

The acid attack test can be conducted on concrete cube immersed into the acid water for curing for 28 days. The acid attack resistance was obtain by the % loss of weight of specimen and the % loss of compressive strength of immersed cubes in acid water.

AID CURING OF CONCRETE CUBES

%LOSS OF WEIGHT REDUCTION OF CUBES AFTER 28DAYS OF 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



%LOSS OF WEIGHT REDUCTION OF CUBES AFTER 28DAYS OF ACID CURING: COMPRESSION STRENGTH OF CUBES AFTER 28DAYS OF ACID CURING

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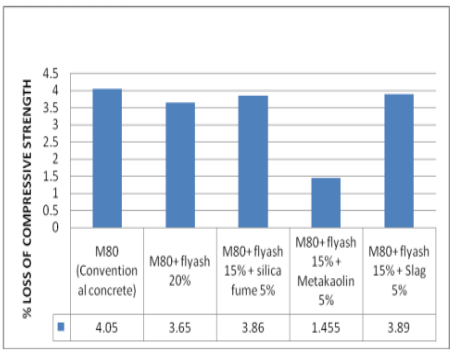
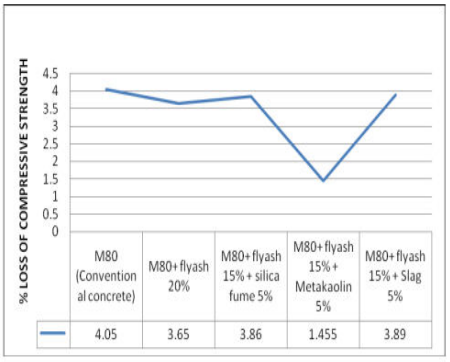
S.NO	GRADE OF CONCRETE	COMPRESSIVE STRENGTH WITH WATER CURING	COMPRESSIVE STRENGTH AFTER ACID CURING	% LOSS IN COMPRESSIVE STRENGTH
1.	M80 (CONVENTIONAL CONCRETE)	74	71	4.05
2.	M80+ FLYASH 20%	82	79	3.65
3.	M80+ FLYASH 15% + SILICA FUME 5%	85.3	82	3.86
4.	M80+ FLYASH 15% + METAKAOLIN 5%	89.3	88	1.455
5.	M80+ FLYASH 15% + SLAG 5%	79.6	76.5	3.89



COMPRESSION STRENGTH OF CUBES AFTER 28DAYS OF ACID CURING



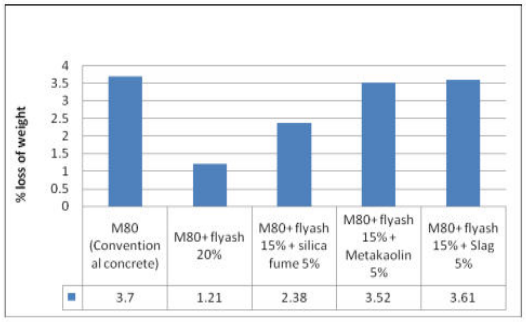
COMPRESSION STRENGTH OF CUBES AFTER 28DAYS OF ACID CURING

VI) ALKALINE 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 and removed from the curing tank allowed drying for 1day.

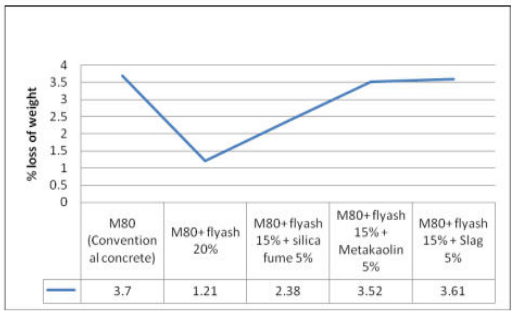
ALKALINE ATTACK TEST OF CONCRETE CUBES

%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+ fly ash 20%	8.2	8.1	1.21
3.	M80+ fly ash 15% + silica fume 5%	8.4	8.2	2.38
4.	M80+ fly ash 15% + Metakaolin 5%	8.5	8.2	3.52
5.	M80+ fly ash 15% + Slag 5%	8.3	8.0	3.61



LOSS OFCOMPRESSIVE STRENGTH REDUCTION OF CUBES AFTER 28DAYS



% LOSS OFCOMPRESSIVE STRENGTH REDUCTION OF CUBES AFTER 28DAYS

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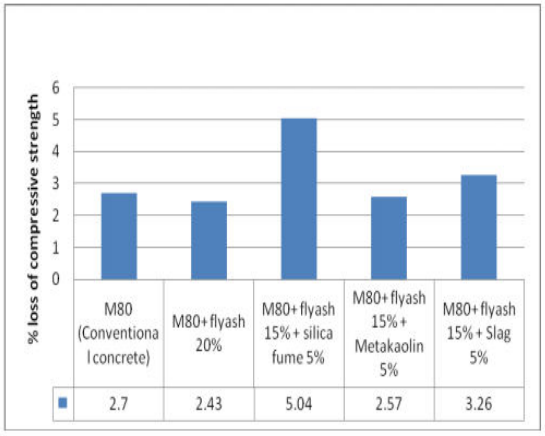
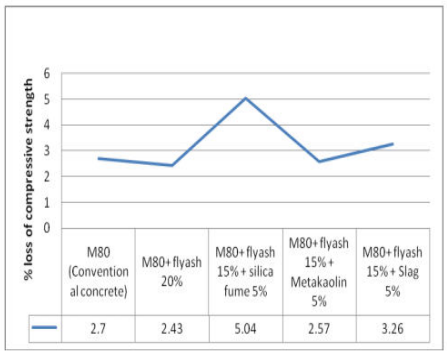
%LOSS OF COMPRESSIVE STRENGTH REDUCTION OF CUBES AFTER 28DAYS ACID CURING:

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+ fly ash 20%	82	80	2.43
3.	M80+ fly ash 15% + silica fume 5%	85.3	81	5.04
4.	M80+ fly ash 15% + Metakaolin 5%	89.3	87	2.57
5.	M80+ fly ash 15% + Slag 5%	79.6	77	3.26



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



%LOSS OF COMPRESSIVE STRENGTH REDUCTION OF CUBES AFTER 28DAYS ALKALINE ATTACK OF CURING:

5.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 combinations of percentage replacement of mineral admixtures gives the
- maximum compressive strength for M80 grade concrete in 89.3 MPa with replacement of
- cement by 15% fly ash and 5% Metakaolin Mineral 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, pre stressed 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.

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