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A Study Of High Performance Concrete By Using Admixture Like Fly Ash,Ggbs,Metakaolin,Silica Fume On M60 Grage 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 M60 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, ggbs& Metakaolin contributed by various reputed industries are used.
In this project work, a brief review presented on "A STUDY OF HIGH PERFORMANCE CONCRETE BY USING ADMIXTURE LIKE FLY ASH, METAKAOLIN,GGBS,SILICA FUME ON M60 GRADE CONCRETE ".
I have compared the combinations of various percentages of admixtures in M60. I presented the combination represented these results in the form of BAR CHARTS and GRAPHS.
The strength tests include compressive, split tube tensile and flexural tests for cubes, cylinders and beams. And durability tests include Acid-Alkali attack tests were conducted and the test results were presented in graphs and bar charts.

1.INTRODUCTION

1.1 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.

1.2 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.

1.3 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 >60.

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.

1.4 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.

2.LITERATURE REVIEW

2.1 GENERAL

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

2.2 REVIEW OF LITERATURE

A. A. Momin et al., (2018), Mix proportioning is the process which involves the determination of correct combination of its ingredients such that the resulting mix yields desired characteristics at its lowest possible cost. The proportioning of HPC requires a special method of mix design as compared to NSC because of its lower water-binder ratio and use of different chemical admixtures and supplementary cementitious materials that would change the properties of concrete in both fresh and hardened state. Chemical admixture is a must for the production of HPC to achieve the desired strength. The effect of admixture on the type of cement should be verified using trail mixes, as HPC uses both chemical and mineral admixtures (SCM). For the strength greater than 70 MPa, silica fume is a must for the production of HPC. BIS method of mix design is applicable for a maximum compressive strength of 40Mpa hence it cannot be applied directly for HPC. The mix proportions for the present study is carried out by the popular method proposed by Aitcin [MehtaP.K. and Aitcin P.C, 1990; Aitcin P.C, 1998]. Concrete of strengths 60, 80 and 100 MPa were developed by using locally available FA and CA with OPC 53 grade cement, SCM and superplasticizer.

Goddalla Durga Prasad et al., (2017), High performance concrete (HPC) is a concrete meeting special combinations of performance and uniformity requirements. This leads to examination of the various admixtures to improve the performance of the concrete. The usage of mineral admixtures in the concrete not only enhances its strength properties but also durability. To study the role of silica fume and ground granulated blast furnace slag (GGBS) on concrete strength characteristics of a high-strength test program has been planned. Different concrete mixtures were prepared and tested with different levels of cement replacement (0 %, 10%, 20 %, 30% and 40 %) of GGBS with active silica fume as addition (0 %, 5 %, 10 % and 15 % by weight of cement). The main objective of this study is to determine the optimal replacement percentages that can be appropriately used in Indian conditions. To find the optimal replacement GGBS with the addition of silica fume in M60 grade concrete with maintaining water cement ratio of 0.32. This experiment is planned to compare 7days and 28days the strength parameters of concrete i.e., compressive strength, split tensile strength and flexural strength. And also workability and durability characteristics were examined.

Kottu Nagababu et al., (2017), this study we optimize the percentage of silica fume in both the aspects of strength and economical .this study we choose M60 grade of concrete and replace silica fume partially with cement by varying percentages such as 0%(control mix),3%,6%,9%,12%,15%,18%.and tested for compressive and tensile strength based on the results. We finalized the optimum percentage of silica fume. it is found that compressive strength increased by about 21%, flexural strength by 35% and split tensile strength by 10% when silica fume reduction in cement content at fixed water cement ratio was not detrimental to fresh and hardened concrete properties and may actually improve performance when silica fume was added as 10% by weight of cement content.

Anjali Prajapati et al., (2017), 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 perIndian standards “Guide for selecting proportions for high strength concrete with Pozzolana Portland cement and other cementitious materials”

3.EXPERIMENTAL PROGRAMME

3.1 PURPOSE

In this project I planned to conduct the lab investigation using mineral and chemical admixtures in different proportions, grade of concrete is **M 60**

The tests were conducted for the concrete are as follows:

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

3.2 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.

3.3 MATERIALS USED IN PRESENT PROJECT AND THEIR PROPERTIES

In the present investigation the following materials were used:

- KCP-53 grade cement conforming to IS: 12269 – 1987.
- Fine aggregate and coarse aggregate conforming to IS: 383 – 1970.
- Admixtures.

3.3.1 CEMENT

Cement is binding material which is the combination of raw materials called calcareous and argillaceous materials. KCP-53 grade ordinary Portland cement conforming to IS: 12269 were used in concrete. Generally a good cement possesses following properties

- Provides strength to masonry.
- Stiffens or hardens early.
- Possesses good plasticity.
- Easily workable.

TABLE – 3.1 PHYSICAL PROPERTIES OF KCP- 53 GRADE CEMENT

Sl.No.	Properties	Test results	IS: 12269-1987

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.	Normal consistency	0.30	
2.	Initial setting time	40min	Minimum of 30min
3.	Final setting time	410min	Maximum of 600min
4.	Specific gravity	3.16	
5.	Compressive strength		
	(a) 3days strength	27.4Mpa	Minimum of 27Mpa
	(b) 7days strength	43.8Mpa	Minimum of 40Mpa
	(c) 28days strength	54.53Mpa	Minimum of 53Mpa

3.3.2 AGGREGATES

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

Table: 3.2 Physical Properties Of Course Aggregate

S.No	Property	Result
1	Fineness Modulus	7.715
2	Specific Gravity	2.65
3	Bulk Density	
	Loose State	1.161gm/cc
	Compacted State	1.478 gm/cc

Table: 3.3 Sieve Analysis Results for Coarse Aggregate

Weight of Coarse aggregate sample taken is 5000 gms

S.No	IS Sieve size	Wt. Retained in gms	Wt retained %	Cumulative Wt. Retained %	% Passing

1	40mm	0	0	0	0
2	20mm	0	0	0	0
3	10mm	870	17.5	17.5	82.4
4	4.75mm	4130	82.5	100	17.6
5	2.36mm	0	0	100	0
6	1.18mm	0	0	100	0
7	600µ	0	0	100	0
8	300µ	0	0	100	0
9	150µ	0	0	100	0
10	90µ	0	0	100	

Fineness Modulus of Coarse Aggregate = 717.5 / 100

=7.175

Table: 3.4 Physical Properties of Fine Aggregate

S.No	Property	Result
1	Fineness Modulus	2.698
2	Specific Gravity	2.7
3	Bulk Density	
	Loose State	1.680 gm/cc
	Compacted State	1.812 gm/cc

Table: 3.5 Sieve Analysis Results for Fine Aggregate

Weight of fine aggregate sample taken 1000gms

S.No	IS Sieve size	Weight retained in Gms	% weight retained	Cumulative % weight retained	% passing

1	10mm	0	0	0	100
2	4.75mm	0	0	0	100
3	2.36mm	24	2.4	2.4	97.7
4	1.18mm	13	13	15.4	86.9
5	600µ	432	43.2	58.6	56.7
6	300µ	348	34.8	93.4	65.5
7	150µ	66	6.6	100	93.2

Fineness Modulus of Fine Aggregate = $\frac{269.8}{100}$

=2.698 Fine aggregate conforming to

Grading Zone- II of IS 383-1970.

4.MIX DESIGN

4.1 MIX DESIGN FOR M60:

STIPULATIONS FOR PROORTIONING:

Grade designation = M60

Type of cement = OPC 53 grade

Mineral admixture = Fly ash, micro silica, ggbs, metakaolin

Maximum nominal size aggregate = 20 mm

Maximum water content = 0.4

Workability = 100mm (slump)

Exposure condition = Severe (reinforced concrete)

Degree of supervision = Good

Type of aggregate = Crushed angular aggregate

Minimum cement content = 360kg/m3

TEST DATA FOR MATERIAL:

Cement used = OPC 53

Specific gravity of cement = 3.16

Specific gravity

Coarse aggregate = 2.65

Fine aggregate = 2.7

Water absorption

Coarse aggregate = 0.7 percent

Fine aggregate = 0.9 percent

Free moisture in

Coarse aggregate = Nil

Fine aggregate = Nil

4.2 DESIGN

Target strength for mix proportion

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

$= 60 + 1.65 \times 5$

$= 68.25\ N/mm^2$ SELECTION OF WATER – CONTENT RATIO:

From table 5 of IS456-2000 maximum w/c = 0.4

SELECTION OF WATER CONTENT:

Maximum water content for 20 mm aggregate = 186 lit

Estimate water content for 100mm slump = $186 + \frac{6}{100} \times 186$

= 197 lit

CALCULATION OF CEMENT CONTENT:

Water cement ratio = 0.4

Cement material content = 197/0.4

= $492.5\ kg/m^3$

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

Volume of coarse aggregate corresponding to 20 mm size and fine aggregate zone 3 for water – cement ration 0.4 = 0.64

As the w/c is lower by 0.10 the proportion of volume of coarse aggregate is increased by 0.02. Therefore for w/c 0.4

Volume of coarse aggregate = 0.64+0.02

= 0.66

For pumpable concrete course aggregate content reduce 10%

= 0.66x0.9

= 0.594

Volume of fine aggregate = 1 – 0.594

= 0.406

MIX PROPORTION:

Cement = 492.5 kg/m^3

Water = 197 kg/m^3

Fine aggregate = 709.24kg/ m^3

Coarse aggregate = 1018 kg/m^3

W/C = 0.4

TABLE 4.1 MIX PROPORTION FOR M80 CONCRTE

Cement	Fine aggregate	Coarse aggregate	Water
492.5	709.24	1018	197
1	1.44	2.06	0.4

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.

5.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. If the concrete subsides evenly all round, the slump measured is true slump. If one half of the cone slides down an inclined plane, a shear slump is said to have taken place and the test has to be repeated. Too wet mix shows collapsible nature of slump.

TABLE: 5.1 TEST RESULTS FOR WORKABILITY

Sl. No	Grade of concrete	Workability Slump (mm)
1.	M-60 (Conventional concrete)	95
2.	M60+FLYASH 20%	91
3.	M60+FLYASH 15%+SILICA FUME 5%	88
4.	M60+FLYASH 15%+METAKAOLIN10%	89

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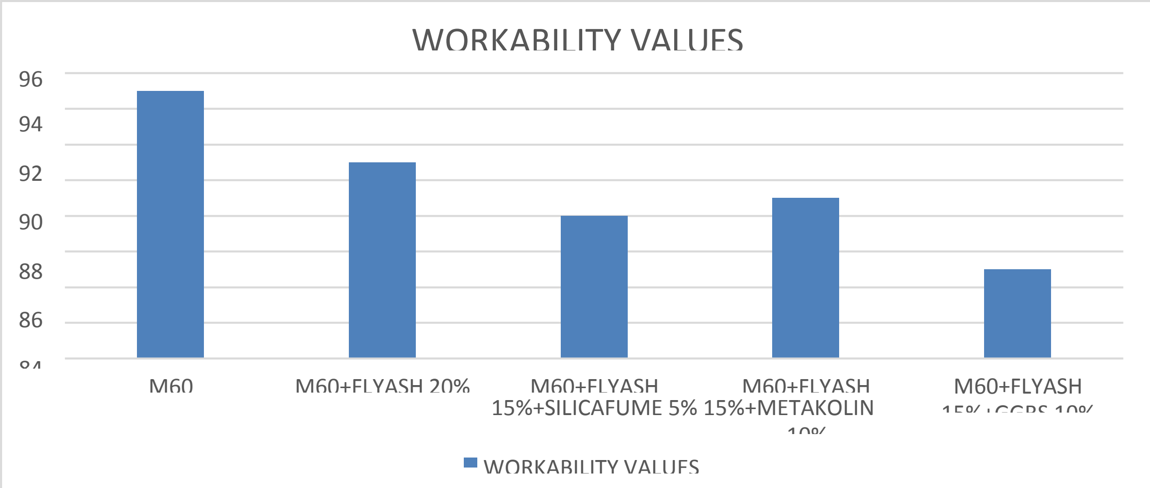
5.	M60+FLY ASH 15%+GGBS SLAG 10%	85



GRAPH:5.1 TEST RESULTS FOR WORKABILITY

5.2 COMPRESSIVE STRENGTH

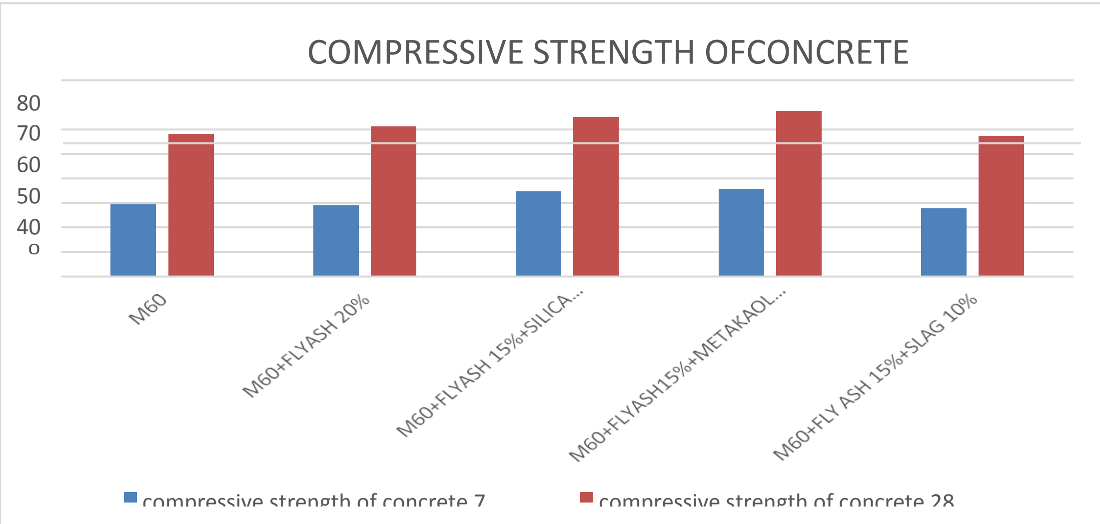
Compression is the test commonly conducted for concrete, so that we can obtain the quality properties. The size of the cube specimen 15cm X 15cm X 15cm was cast to test various concrete mixtures for compressive strength. After moulding, kept for curing for 7 days and 28 days the compressive strength 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:5.2 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.	M60	29.4	58.2
2.	M60+FLYASH 20%	29.1	61.2
3.	M60+FLYASH 15%+SILICA FUME 5%	34.8	64.98
4.	M60+FLYASH15%+METAKAOLIN10%	35.7	67.38
5.	M60+FLY ASH 15%+SLAG 10%	27.72	57.36



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

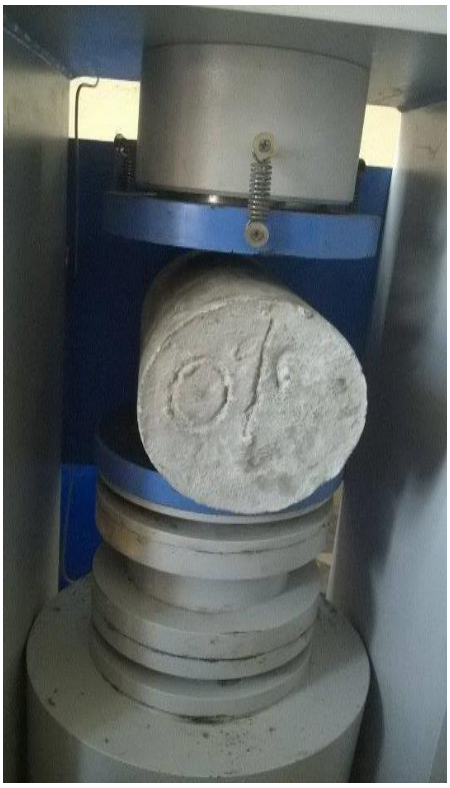


FIGURE 5.3: SPLIT TUBE TENSILE TEST APPARATUS

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

Where,

P = maximum tensile load

L = length of the cylinder

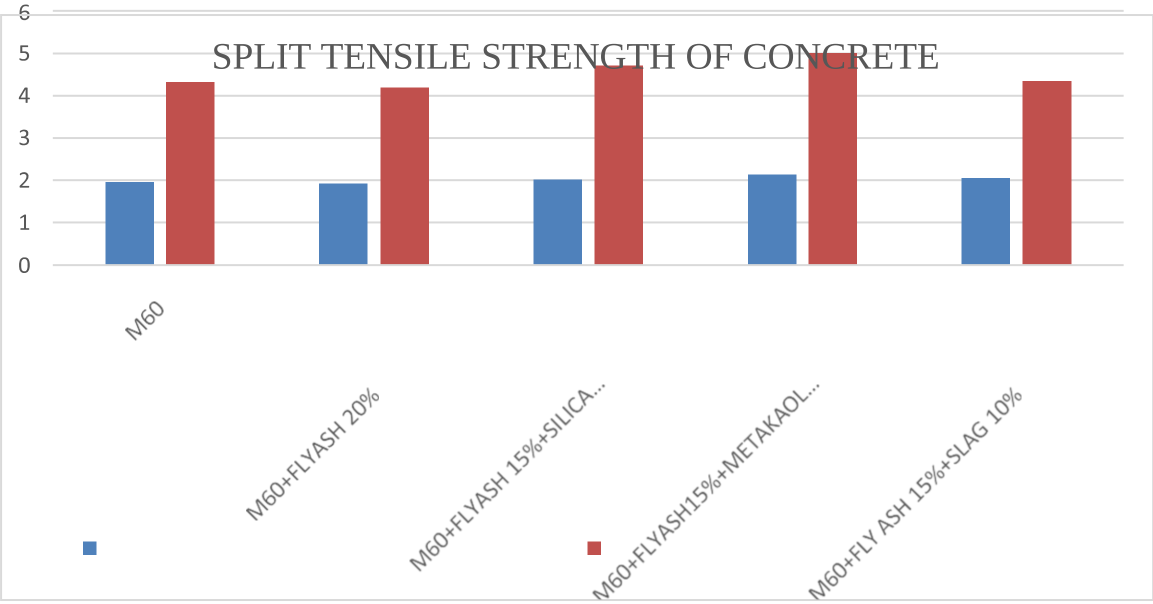
d = diameter of the cylinder

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

Sl.NO	GRADE OF CONCRETE	SPLIT-TENSILE STRENGTH OF 7 DAYS (MPA)	SPLIT-TENSILE STRENGTH OF 28 DAYS (MPA)
1.	M60	3.25	7.2
2.	M60+FLYASH 20%	3.2	7.0
3.	M60+FLYASH 15%+SILICA FUME 5%	3.1	6.5
4.	M60+FLYASH15%+METAKAOLIN10%	3.35	7.5
5.	M60+FLY ASH 15%+SLAG 10%	3.145	7.1

GRAPH: 5.3 TENSILE TESTS FOR 7 DAYS AND 28 DAYS



5.4 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 f_b, which if 'a' equals the distance between line of fracture and the near su pport, measured on the centre line of the tensile side of the specimen, in cm, is calculated to the nearest 0.0005 MPa as follows:

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

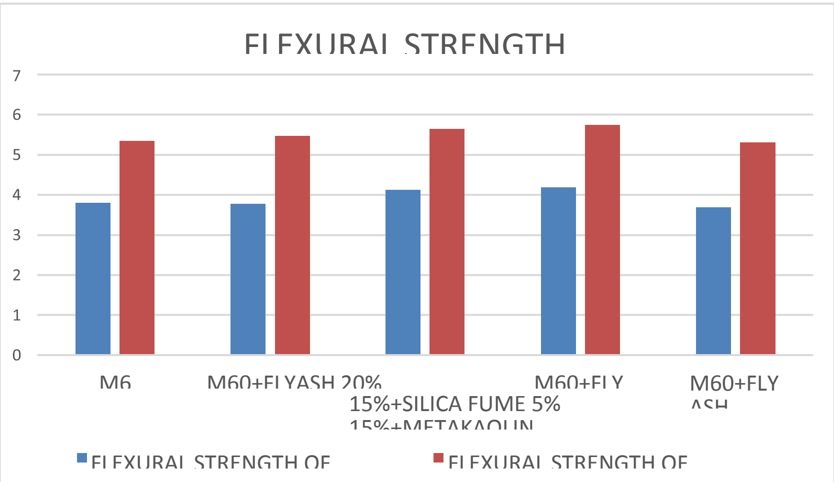
when 'a' is greater than 20.0 cm for 15.0 cm specimen, or

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

FIGURE:5.4 FLEXURAL STRENGTH BY ONE-POINT METHOD

TABLE: 5.4 FLEXURALTEST FOR 7 DAYS AND 28 DAYS

S.NO	GRADE OF CONCRETE	FLEXURAL STRENGTH OF 7 DAYS (MPA)	FLEXURAL STRENGTH OF 28 DAYS (MPA)
1.	M60	3.15	7.1
2.	M60+FLYASH 20%	3.08	6.9
3.	M60+FLYASH 15%+SILICA FUME 5%	3	6.5
4.	M60+FLYASH 15% + METAKAOLIN 10%	3.45	7.45
5.	M60+FLY ASH 15%+SLAG 10%	3.075	6.85



GRAPH: 5.4 FLEXURALTEST FOR 7 DAYS AND 28 DAYS

5.5 ACID ATTACK TEST

The acid attack test can be conducted on concrete cube immersed into the acid water for curing for28 days. The acid attack resistance was obtain by the % loss of weight of specimen and the % loss of compressive strength of immersed cubes inacid water.

FIGURE:5.5: ACID CURING OF CONCRETE CUBES

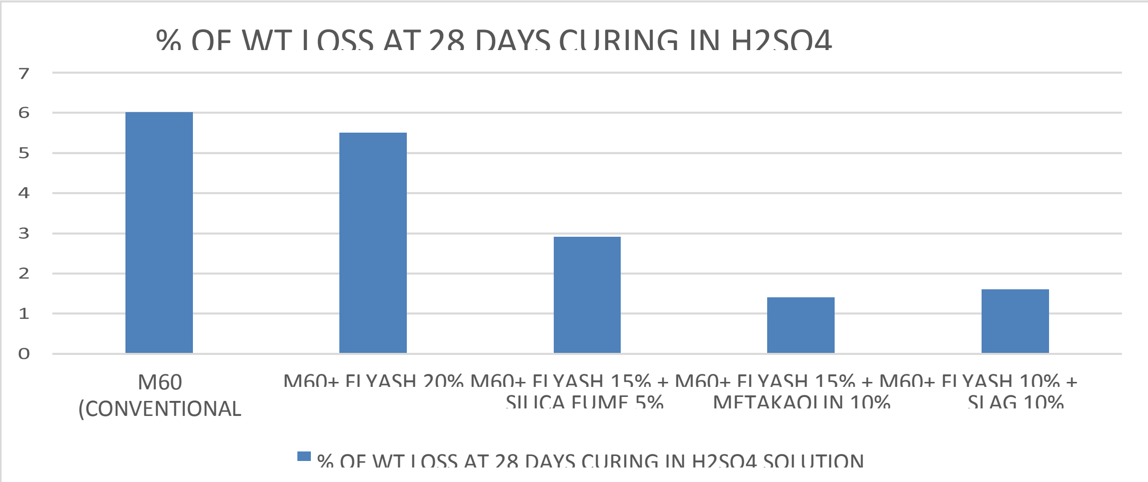
For acid attack test concrete cube of size 150 ×150 ×150 mm are prepared for various percentages of silica fume, metakoilin, ggbs and fly ash addition. The specimen are cast and cured in mould for 24 hours, after 24 hours, all the specimen are demoulded and kept in curing tank for 7-days. After 7-days all specimens are kept in atmosphere for 2-days for constant weight, subsequently, the specimens are weighed and immersed in 5% sulphuric acid (H_2SO_4) solution for 60-days. The pH value of the acidic media was at 0.3.

The pH value was periodically checked and maintained at 0.3. After 60-days of immersing in acid solution, the specimens are taken out and were washed in running water and kept in atmosphere for 2-day for constant weight. Subsequently the specimens are weighed and loss in weight and hence the percentage loss of weight was calculated.

TABLE5.5: %LOSS OF WEIGHT REDUCTION OF CUBES AFTER 28DAYS OF ACID CURING:

S.NO	GRADE OF CONCRETE	INITIAL WEIGHT	FINAL WEIGHT	% LOSS IN WEIGHT
1.	M60 (CONVENTIONAL CONCRETE)	8.45	7.85	6
2.	M60+ FLYASH 20%	8.65	8.1	5.5
3.	M60+ FLYASH 15% + SILICA FUME 5%	8.5	8.21	2.9
4.	M60+ FLYASH 15% + METAKAOLIN 10%	8.44	8.3	1.4

5.	M60+ FLYASH 10% + SLAG 10%	8.32	8.16	1.6



GRAPH 5.5: % LOSS OF WEIGHT REDUCTION OF CUBES AFTER 28DAYS OF ACID CURING

5.6 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.

FIGURE 5.6: ALKALINE ATTACK TESTOF CONCRETE CUBES TABLE: 5.6%LOSS OF WEIGHT REDUCTION OF CUBES AFTER 28DAYS

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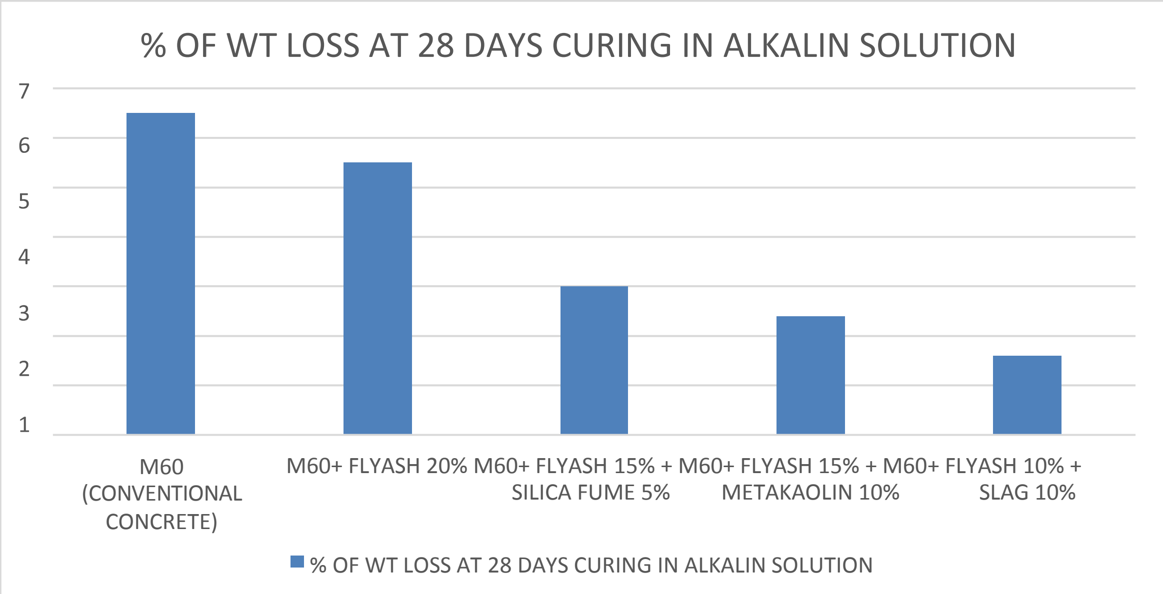
S.NO	GRADE OF CONCRETE	INITIAL WEIGHT	FINAL WEIGHT	% LOSS IN WEIGHT
1.	M60 (CONVENTIONAL CONCRETE)	8.45	7.8	6
2.	M60+ FLYASH 20%	8.65	8.1	4.75
3.	M60+ FLYASH 15% + SILICA FUME 5%	8.5	8.2	6
4.	M60+ FLYASH 15% + METAKAOLIN 10%	8.44	8.2	4.75
5.	M60+ FLYASH 10% + SLAG 10%	8.32	8.0	3.61



GRAPH 5.6: % LOSS OFCOMPRESSIVE STRENGTH REDUCTION OF CUBES AFTER 28DAYS

CONCLUSION

- 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 M60 grade concrete in67.38Mpa with replacement of cement by15% fly ash and 10% Metakaolin Mineral admixtures such as Fly ash, micro silica, metkaolin & Slag also contribute effectively for achieving high strength.
- In case of different combinations of percentage replacement of mineral admixtures gives the maximum split tensile strength for M60grade concrete in 7.5Mpa with replacement of cement by15% fly ash and 5% Metakaolin Mineral admixtures such as Fly ash, micro silica, metkaolin & Slag also contribute effectively for achieving high strength.
- In case of different combinations of percentage replacement of mineral admixtures gives the maximum flexural strength for M60 grade concrete in 7.45Mpa with replacement of cement by15% 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, 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.

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