Comparative analysis of standard concrete with partial replacement of cement by using metakaolin and silica fume and partial replacement of coarse aggregates by brick bats

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ABSTARCT: Metakaloin (MK) and silica fume (SF) is a popular type of natural pozzolanic material which has been widely utilized in constructions since ancient times and silica fume is the largest group of silicate minerals. The present study is, carried out in two phases in first phase mix of M30 grade concrete with partial replacement of cement by 0%, 10%, 15%, 20%, and 25% Metakaolin (MK) and silica fume (SF) both are mixed with same percentages is carried out to determine the optimum percentage of replacement at which maximum compressive strength, tensile strength, flexural strength is achieved. It is observed that- when cement is partially replaced with 15% of MK+SF concrete maximum strength is achieved. In phase two mix of M40 grade concrete combination of Silica Fume and metakaolin is -partially replaced with cement. The composition 15% of silica fume constant + 5%, 10%, 15%, 20% of metakaolin is carried out to determine the maximum strength. It is observed that when cement is partially replaced with 15 % of silica fume + 10 % of metakaolin concrete maximum strength is achieved. The coarse aggregates are replaced by brick bats with the 0% , 20 % , and 40 % replacements in the M40 grade

Keywords :Metakaolin (MK), silica fume (SF) , Mechanical properties , durability properties

I.INTRODUCTION

Concrete is one of most extensively used construction materials in the world, with two billion tons placed worldwide each year It is attractive in many applications because it offers considerable strength at a relatively low cost. Portland cement industry is responsible for approximately 7% of global CO2 emission. Partial replacement of Portland cements by one or more additives to obtain blended cements not only provides reduction in CO^2 emission and energy saving in cement product. ion but also supplies more durable cementitious systems to construction industry. Concrete is a composite construction material composed primarily of aggregate, cement and water. In view waste materials disposed from industries and or pozzolana materials containing reactive silica or alumina are used in mixing with Portland cement reacts with lime produced by cement hydration in the presence of water and thus forms harden with cement.Replacing cement with Metakaolin combines with calcium hydroxide change the micro structure of the concrete and chemistry of hydration products and production of C-S-H, resulting in an increased strength and reduces the porosity and therefore improved durability.Fine aggregate is an essential component of concrete. The global consumption of natural river sand is very high due to the extensive use of concrete.The non-availability of sufficient quantity of ordinary river sand for making cement concrete is affecting the growth of the construction industry in many parts of the country. In order to reduce the dependence on natural aggregates as the main source of aggregates in concrete, artificially manufactured aggregates and artificial aggregates generated from industrial wastes provide an alternative for the construction industry .

SILICA FUME

Silica fume, also known as **micro silica**, is an amorphous (non-crystalline) polymorph of silicon dioxide, silica. It is an ultrafine powder collected as a by-product of the silicon and ferrosilicon alloy production and consists of spherical particles with an average particle diameter of 150 nm. The main field of application is as pozzolanic material for high performance concrete.

Physical and Chemical Properties of Silica Fume

Properties	OPC	Silica Fume
Physical		
Specific gravity	3.1	2.2
Mean grain size (µm)	22.5	0.15
Specific area cm^2/gm	3250	150000-300000
Colour	Dark Grey	Light to Dark Grey
Chemical compositions (%)		
Silicon dioxide (SiO_2)	20.25	85
Aluminium oxide (Al_2O_3)	5.04	1.12
Iron oxide (Fe_2O_3)	3.16	1.46
Calcium oxide (CaO)	63.61	0.2-0.8
Magnesium oxide (MgO)	4.56	0.2-0.8
Sodium oxide (Na_2O)	0.08	0.5-1.2
Potassium oxide (K_2O)	0.51	
Loss on ignition	3.12	<6.0

METAKAOLIN

Metakaolin is a pozzolan, probably the most effective pozzolanic material for use in concrete. It is a product that is manufactured for use rather than a by-product and is formed when china clay, the mineral kaolin, is heated to a temperature between 600 and 800ºC. Its quality is controlled during manufacture, resulting in a much less variable material than industrial pozzolans that are by-products. Slightly higher replacement levels (up to 20%) produce a ***cement matrix that has low porosity and permeability. This results in improvements to resistance of the hardened concrete to attack by sulfates, chloride ions and other aggressive substances, such as mineral and organic acids. Freeze/ thaw resistance is improved and the risk of damage resulting from the effects of impact or abrasion is reduced for metakaolin concrete that has been finished and cured properly.***

CHEMICAL PROPERTIES OF METAKAOLIN

Chemical composition	Cement (%)	Metakaolin (%)
Silica (SiO_2)	34	54.3
Alumina (Al_2O_3)	5.5	38.3
Ferric oxide (Fe_2O_3)	4.4	4.28
Calcium oxide (CaO)	63	0.39
Magnesium oxide (MgO)	1.26	0.08
Sodium oxide (Na_2O)	0.1	0.12
Potassium oxide (K_2O)	0.48	0.50
Sulphuric anhydride (SO_3)	1.92	0.22
Loss on ignition (LOI)	1.3	0.68
Blaine (m^2/kg)	360	15,000[a]
Specific gravity	3.15	2.5

PHYSICAL PROPERTIES OF METAKAOLIN

Physical Properties	Cementitious Materials		
	Type 1 Cement	Metakaolin	Silica Fume
Specific gravity	3.09	2.50	2.20
Specific Surface Blaine fineness, m^2/kg	373		
Nitrogen Absorption, m^2/g		16.8	20.9

BRICK BATS

Brickbats are Collected locally and then broken into pieces of 20mm size, mechanically sieved through 4.75mm sieve to remove the finer particles. These rejected bricks can also be a potential source of coarse aggregate.

PROPERTIES OF BRICK BATS WHEN COMPARED TO COARSE AGGREGATES

Properties	Coarse aggregate	Brick bats
Specific gravity	2.85	2.56
Fineness modulus	6.6	-
Water absorption	1.3%	10.09%
Impact value	6.34	17.89

OBJECTIVE OF THE STUDY

- To determine the optimum content of Metakaolin and silica fume as a substitute for cement in concrete;
- To evaluate the mechanical properties (compressive strength) of concrete containing metakaolin and silica fume as Cement replacement in concrete;
- To study the physical properties of concrete materials.
- To arrive a mix design summary for concrete using IS code method. To study the workability of fresh concrete such as slump.
- To study the various strength of hardened concrete such as compressive strength of concrete cubes at 28 days , 56 days and Split tensile strength of cylinder at 28 days, 56 days and Flexural strength of prism at 28 days and 56 days.
- 7To compare the workability and various strength for different percentage of partial replacement of metakaolin and silica fume with ordinary concrete

SUMMARY

Portland cement is the most important ingredient of concrete and is a versatile and relatively high cost material. Large scale production of cement is causing environmental problems on one hand and depletion of natural resources on other hand. This threat to ecology has led to researchers to use industrial by products as supplementary cementations material in making concrete. The main parameter investigated in this study is M35 grade concrete with partial replacement of cement by silica fume by The present study is, carried out in two phases in first phase mix of M35 grade concrete with partial replacement of cement by 0%, 10%, 15%, 20%, and 25% Metakaolin (MK) and silica fume (SF) both are mixed with same percentages , the second trail mix was performed with the 15% of silica fume constant + 5%, 10%, 15%, 20% of metakaolin This paper presents a detailed experimental study on Compressive strength, split tensile strength, flexural strength at age of 28 days and 56 days. The brick bats are also are used in the replacement of 0 %, 20 % and 40 % in the both mixes to find better mix and to find the mechanical properties. Durability study on acid attack was also studied and percentage of weight loss is compared with normal concrete. Test results indicate that use of Silica fume in concrete has improved the performance of concrete in strength as well as in durability aspect.

II.LITERATURE REVIEW

Assem A.A. Hassan a,⇑ , Mohamed Lachemi b,1 , Khandaker M.A. Hossain b,2 et all,.(2012) Metakaolin (MK) is a valuable admixture for concrete/cement applications that can enhance the performance of cementitious composites through high pozzolanic reactivity, much like silica fume (SF). While SF concrete is characterized by superior mechanical and durability performance, concrete containing MK achieves comparable properties at a lower price and with better workability. The objective of this study is to investigate the effect of cement replacement by MK on the durability of self-consolidating concrete (SCC); the effect of SF at similar levels of MK replacement has also been included for comparison. The durability performance of SCC was evaluated based on the results of drying shrinkage, freezing and thawing, salt scaling, and rapid chloride permeability tests. The results of these tests indicate that highly durable SCC mixtures can be produced using a high MK content with an optimum percentage of around 20%. The results also show that the durability of SCC, especially with high MK content, is higher than that of SCC containing SF

REVIEW ON MIX DESIGN

Davidovits J and Sawyer J L , used ground blast furnace slag to produce geopolymer binders. This type of binders patented in the USA under the title Early High-Strength Mineral Polymer was used as a supplementary cementing material in the production of precast concrete products. In addition, a ready-made mortar package that required only the addition of mixing water to produce a durable and very rapid strength gaining material was produced and utilized in restoration of concrete airport runways, aprons and taxiways, highway and bridge decks, and for several new constructions when high early strength was needed. Geopolymer has also been used to replace organic polymer as an adhesive in strengthening structural members. Geopolymers were found to be fire resistant and durable under UV light.

III.MATERIALS AND METHODOLOGY

MATERIALS USED

CEMENT

Cement is a binder, a substance used in construction that sets and hardens and can bind other materials together. The most important types of cement are used as a component in the production of mortar in masonry, and of concrete which is a combination of cement and an aggregate to form a strong building material.

Physical properties of 53 grade cement

S.No	Property	Test Result
1	Standard consistency	32%
2	Specific gravity	3.15
3	Initial setting time (min)	33
4	Final setting time (Hours)	8 hrs
5	Specific Surface Area (m^2/Kg)	385
6	Soundness (mm)	2
7	Compressive strength (N/mm^2)	55
8	Fineness	7%

FINE AGGREGATES

It is the aggregate most of which passes 4.75 mm IS sieve and contains only so much coarser as is permitted by specification. According to source fine aggregate may be described as:

- Natural sand-it is the aggregate resultingfrom the natural disintegration of rock and which has been deposited by streams or glacial agencies.
- Crushed stone sand-it is the fine aggregate produced by crushing hard stone.
- Crushed gravel sand-it is the fine aggregate produced by crushing natural gravel.

S. No	Property	Fine Aggregate
1	Specific Gravity	2.6
2	Bulk Density (Kg/m^3)	1650
3	Fineness Modulus	2.76
4	Absorption (%)	0.1
5	Moisture content (%)	0

COARSE AGGREGATES:

It is the aggregate most of which is retained on 4.75 mm IS sieve and contains only so much finer material as is permitted by specification

S. No	Property	Coarse Aggregate
1	Specific Gravity	2.66
2	Bulk Density (Kg/m^3)	1780
3	Fineness Modulus	6.04
4	Absorption (%)	0.2
5	Moisture content (%)	0

WATER

Water is one of the important ingredient in construction but in present day quality of water is not given such big importance. Water is used in construction industry for various purpose such as for preparing mortar, mixing of cement concrete and for curing work etc during construction work. The quality and quantity of water plays a major role in determining the strength of mortar and cement concrete in construction work.

SUPER PLASTICIZER AND ADDITIVES:

Super plasticizers are capable of reducing water contents by about 30 percent. However it is to be noted that full efficiency of super plasticizer can be got only when it is added to a mix that has as initial slump of 20 to 30 mm. stiff concrete mix reduces its water reducing efficiency by adding super plasticizer. Depending on the solid content of the mix, a dosage of 1 to 3 percent by weight is recommended.

Problem statement for M30 grade concrete

SI.No	% Replacement by cement by MK+SF	% Replacement Of CA by bricks bats	Compressive strength of concrete				Split tensile strength of concrete		Flexural strength of concrete		Durability test
			7days	28days	56days	90days	28days	56days	28days	56days	90 days
1	0.00%	0 %	3	3	3	3	3	3	3	3	3
2	10%	20 %	3	3	3	3	3	3	3	3	3
3	15%	20%	3	3	3	3	3	3	3	3	3
4	20%	40%	3	3	3	3	3	3	3	3	3
5	25%	40%	3	3	3	3	3	3	3	3	3
Total			60				30		30		15

Problem statement for M40 grade concrete

SI.No	% Replacement	% Replacement Of CA by brick bats	Compressive strength of concrete				Split tensile strength of concrete		Flexural strength of concrete		Durability test
			7days	28 days	56days	90days	28days	56days	28days	56days	90 days
1	0.00%	0 %	3	3	3	3	3	3	3	3	3
2	10 MK+5% SF	20%	3	3	3	3	3	3	3	3	3
3	10MK+10%SF	20%	3	3	3	3	3	3	3	3	3
4	10MK+15% SF	40%	3	3	3	3	3	3	3	3	3
5	10MK+20%SF	40%	3	3	3	3	3	3	3	3	3
Total			60				30		30		15

MIX DESIGN

FOR M30 GRADE CONCRETE

S.no	Cement	Fine aggregate	Bottom Ash	Foundry sand	Coarse aggregate	water
	292 kgs	360	58.575	58.575	742	132
Addition of 10 %	321.20 kgs	396	64.4325	64.4325	816.20	145.20

FOR M40 GRADE CONCRETE

S.no	Cement	Fine aggregate	METAKAOLIN	SILICA FUME	Coarse aggregate	admixture	water
1	269 kgs	356	44.33	44.33	785	0.900	119
Addition of 10 %	295.90 kgs	391.60	48.763	48.763	863.50	0.99	130.90

Test to be conducted on the specimens

Cement

i. Determination setting time

ii. Standard consistency test

iii. Specific gravity of cement

iv. Fineness of cement

Fine aggregate

i. Bulking of fine aggregates

ii. Determination of bulk density and voids

iii. Specific gravity

Coarse aggregate

i. Specific gravity

ii. Crushing value test

iii. Impact test

Tests on concrete

i. Slump cone test

ii. Compaction factor test

iii. Compressive strength of concrete

iv. Split tensile strength

v. Flexural strength test

vi durability test

IV.TEST RESULTS AND ANALYSIS

MATERIAL PROPERTIES:

A. CEMENT:

Sl.No	Test	Results	IS code used	Acceptable limit
1	Specific gravity of cement	3.150	IS:2386:1963	3 to 3.2
2	Standard consistency of cement	7mm at 34% w/c	IS:4031:1996	w/c ratio 28%-35%
3	Initial and final setting time	55 mins and 10 hours	IS:4031:1988	Minimum 30mins and should not more than 10 hours
4	Fineness of cement	5.00%	IS:4031:1988	<10%

COARSE AGGREGATES

Sl.No	Test	Results	Is code used	Acceptable limit
1	Fineness modulus	7	IS:2386:1963	6.0 to 8.0mm
2	Specific gravity	2.95	IS:2386:1963	2 to 3.1mm
3	Porosity	48.83%	IS:2386:1963	Not greater than 100%
4	Voids ratio	0.8955	IS:2386:1963	Any value
5	Bulk density	1.52g/cc	IS:2386:1963	-
6	Aggregate impact value	39.5	IS:2386:1963	Less than 45%
7	Aggregate crushing value	28.6%	IS:2386:1963	Less than 45%

FINE AGGREGATE

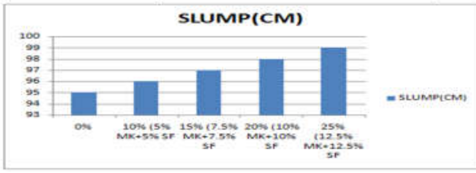
Sl.No	Test	Result	Is code used	Acceptable limits
1	Fineness modulus	3.507	IS:2386:1963	Not more than 3.2 mm
2	Specific gravity	2.68	IS:2386:1963	2.0 to 3.1
3	Porosity	38.6%	IS:2386:1963	Not greater than 100%
4	Voids ratio	0.59	IS:2386:1963	Any value
5	Bulk density	1.95	IS:2386:1963	-
6	Bulking of sand	6.0%	IS:2386:1963	Less than 10%

CONCRETE TESTS

M30 RESULTS

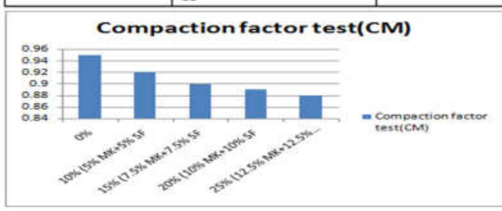
SLUMP CONE TEST:

S.no	Material	SLUMP(CM)
1	0%	95
2	10 % (5% BA+5%FS)	96
3	20%(10%BA+10%FS)	97
3	30%(15% BA+15%FS)	98
4	40%(20%BA+20%FS)	99



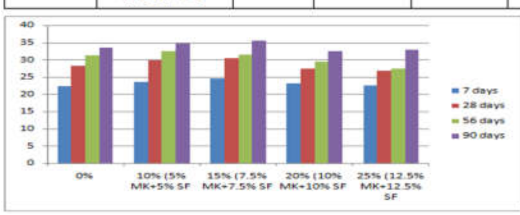
COMPACTION FACTOR TEST

S.no	Material	Compaction factor test(CM)
1	0%	0.95
2	10% (5% MK+5% SF	0.92
3	15% (7.5% MK+7.5% SF	0.9
3	20% (10% MK+10% SF	0.89
4	25% (12.5% MK+12.5% SF	0.88



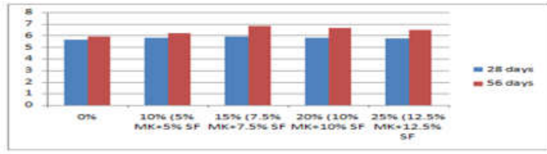
COMPRESSIVE STRENGTH

	% of replacement of fine aggregate	compressive strength kN/m2			
		7 days	28 days	56 days	90 days
1	0%	22.35	28.3	31.25	33.45
2	10% (5% MK+5% SF	23.5	29.8	32.5	34.8
3	15% (7.5% MK+7.5% SF	24.5	30.52	31.55	35.6
4	20% (10% MK+10% SF	23.2	27.5	29.5	32.5
5	25% (12.5% MK+12.5% SF	22.5	26.8	27.5	32.8



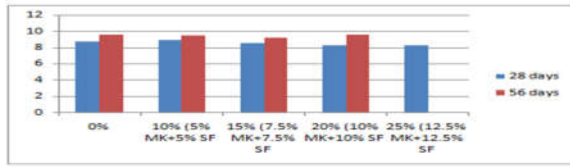
SPLIT TENSILE STRENGTH

	% of replacement of fine aggregate	split tensile strength kN/m2	
		28 days	56 days
1	0%	5.62	5.9
2	10% (5% MK+5% SF	5.81	6.2
3	15% (7.5% MK+7.5% SF	5.92	6.8
4	20% (10% MK+10% SF	5.83	6.65
5	25% (12.5% MK+12.5% SF	5.75	6.5



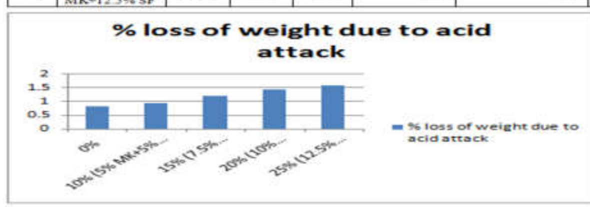
FLEXURAL STRENGTH

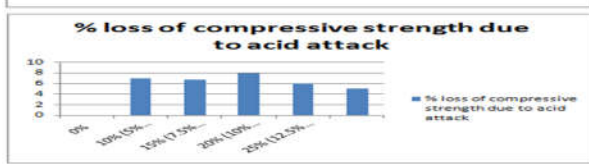
	% of replacement of fine aggregate	flexural strength kN/m2	
		28 days	56 days
1	0%	8.69	9.6
2	10% (5% MK+5% SF	8.9	9.5
3	15% (7.5% MK+7.5% SF	8.5	9.23
4	20% (10% MK+10% SF	8.23	9.6
5	25% (12.5% MK+12.5% SF	8.24	`9.75



DURABILITY TEST

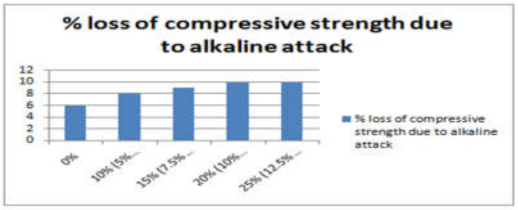
Sl.no	% of replacement of fine aggregate	Initial weight of cube after 28days curing in grams	Final weight of cubes after 90days curing in grams	% loss of weight due to acid attack	Compressive strength of cube after 28days curing	Compressive strength of cubes after 90days curing	% loss of compressive strength due to acid attack
1	0%	2261	2242	0.82	40.52	33.5	7.02
2	10% (5% MK+5% SF	2340	2318	0.94	38.25	31.5	6.75
3	15% (7.5% MK+7.5% SF	2351	2323	1.2	38.5	30.5	8
4	20% (10% MK+10% SF	2234	2202	1.44	37.5	31.5	6
5	25% (12.5% MK+12.5% SF	2394	2356	1.6	37.5	32.5	5

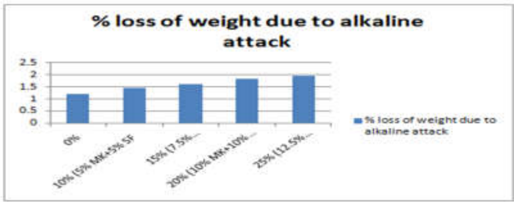




ALKALINE ATTACK

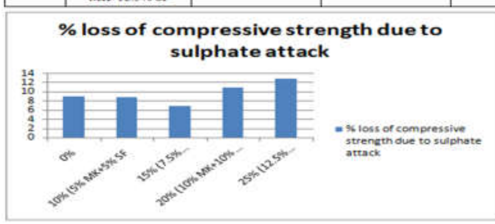
Sl. No	% replacement	Initial weight of cube after 28days curing in grams	Final weight of cubes after 90days curing in grams	% loss of weight due to alkaline attack	Compressive strength of cube after 28days curing	Compressive strength of cubes after 90days curing	% loss of compressive strength due to alkaline attack
1	0%	2286	2259	1.2	41.5	35.6	5.9
2	10% (5% MK+5% SF	2340	2306	1.44	39.5	31.5	8
3	15% (7.5% MK+7.5% SF	2280	2244	1.6	38.5	29.5	9
4	20% (10% MK+10% SF	2310	2268	1.84	39.5	29.5	10
5	25% (12.5% MK+12.5% SF	2296	2251	1.96	34.5	24.6	9.9





SULPHATE ATTACK TEST

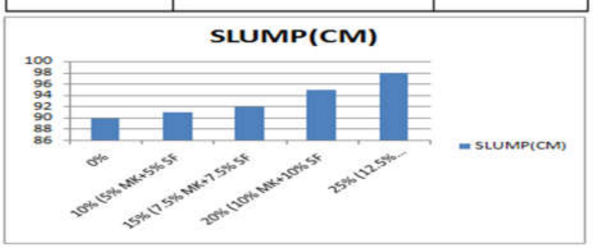
Sl.no	% replacement	Compressive strength of cube after 28days curing	Compressive strength of cubes after 90days curing	% loss of compressive strength due to sulphate attack
1	0%	39.6	30.5	9.1
2	10% (5% MK+5% SF	42.5	33.6	8.9
3	15% (7.5% MK+7.5% SF	41.5	34.5	7
4	20% (10% MK+10% SF	36.5	25.5	11
5	25% (12.5% MK+12.5% SF	34.5	21.5	13



MIX DESIGN OF M40

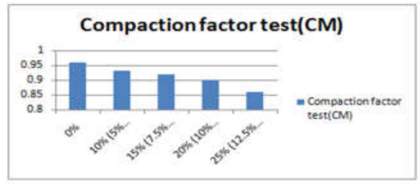
SLUMP CONE TEST

S.no	replacement of cement	SLUMP(CM)
1	0%	90
2	10% (5% MK+5% SF	91
3	15% (7.5% MK+7.5% SF	92
3	20% (10% MK+10% SF	95
4	25% (12.5% MK+12.5% SF	98



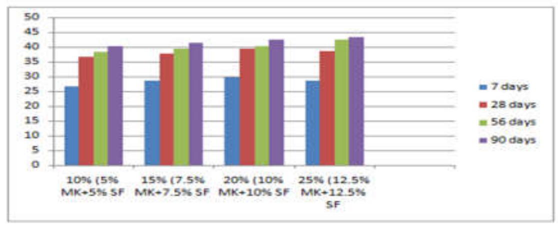
COMPACTION FACTOR TEST

S.no	replacement of cement	Compaction factor test(CM)
1	0%	0.96
2	10% (5% MK+5% SF	0.93
3	15% (7.5% MK+7.5% SF	0.92
3	20% (10% MK+10% SF	0.9
4	25% (12.5% MK+12.5% SF	0.86



COMPRESSIVE STRENGTH

S.NO	replacement of cement	compressive strength kN/m2			
	0%	7 days	28 days	56 days	90 days
1	10% (5% MK+5% SF	26.8	36.8	38.4	40.21
2	15% (7.5% MK+7.5% SF	28.5	37.8	39.4	41.5
3	20% (10% MK+10% SF	29.6	39.4	40.25	42.6
4	25% (12.5% MK+12.5% SF	28.6	38.5	42.5	43.26

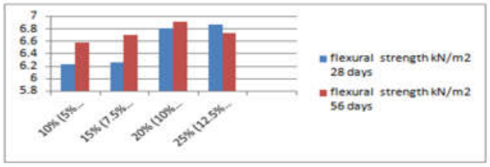


SPIT TENSILE STRENGTH

	replacement of cement	split tensile strength kN/m2	
	0%	28 days	56 days
1	10% (5% MK+5% SF	8.69	9.6
2	15% (7.5% MK+7.5% SF	8.9	9.5
3	20% (10% MK+10% SF	8.5	9.23
4	25% (12.5% MK+12.5% SF	8.23	9.6

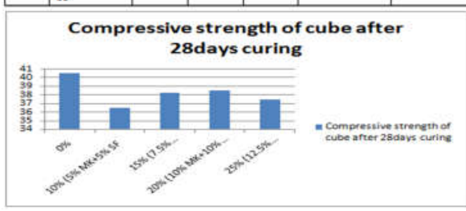
FLEXURAL STRENGTH

	replacement of cement	flexural strength kN/m2	
	0%	28 days	56 days
1	10% (5% MK+5% SF	6.23	6.58
2	15% (7.5% MK+7.5% SF	6.25	6.7
3	20% (10% MK+10% SF	6.8	6.91
4	25% (12.5% MK+12.5% SF	6.86	6.72



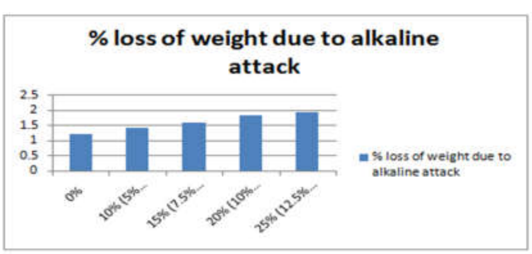
DURABILITY TEST

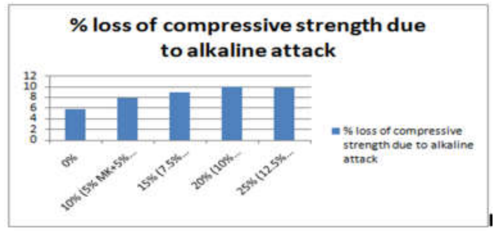
Sl.no	replacement of cement	Initial weight of cube after 28days curing in grams	Final weight of cubes after 90days curing in grams	% loss of weight due to acid attack	Compressive strength of cube after 28days curing	Compressive strength of cubes after 90days curing	% loss of compressive strength due to acid attack
1	0%				40.52	33.5	7.02
	10% (5% MK+5% SF	2261	2242	0.82	36.5	32	4.5
2	15% (7.5% MK+7.5% SF	2340	2318	0.94	38.25	31.5	6.75
3	20% (10% MK+10% SF	2351	2323	1.2	38.5	30.5	8
4	25% (12.5% MK+12.5% SF	2234	2202	1.44	37.5	31.5	6



ALKALINE ATTACK

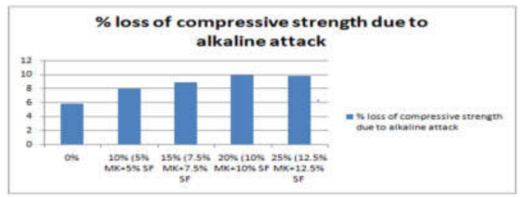
Sl. No	% replacement	Initial weight of cube after 28days curing in grams	Final weight of cubes after 90days curing in grams	% loss of weight due to alkaline attack	Compressive strength of cube after 28days curing	Compressive strength of cubes after 90days curing	% loss of compressive strength due to alkaline attack
1	0%	2286	2259	1.2	41.5	35.6	5.9
2	10% (5% MK+5% SF	2340	2306	1.44	39.5	31.5	8
3	15% (7.5% MK+7.5% SF	2280	2244	1.6	38.5	29.5	9
4	20% (10% MK+10% SF	2310	2268	1.84	39.5	29.5	10
5	25% (12.5% MK+12.5% SF	2296	2251	1.96	34.5	24.6	9.9





SULPHATE ATTACK TEST

Sl.no	% replacement	Compressive strength of cube after 28days curing	Compressive strength of cubes after 90days curing	% loss of compressive strength due to sulphate attack
1	0%	39.6	30.5	9.1
2	10% (5% MK+5% SF	42.5	33.6	8.9
3	15% (7.5% MK+7.5% SF	41.5	34.5	7
4	20% (10% MK+10% SF	36.5	25.5	11
5	25% (12.5% MK+12.5% SF	34.5	21.5	13



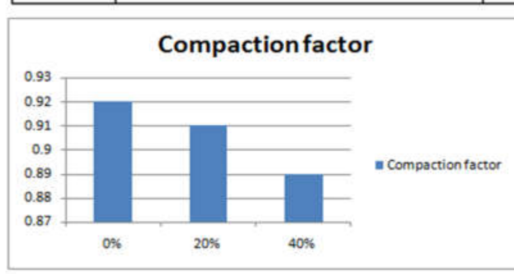
TRAIL MIX OF M40 GRADE OF CONCRTE WITH PARTIAL REPLACEMENT OF BRICK BATS

SLUMP CONE TEST

S.NO	% REPLACEMENT Coarse aggregates by brick bats	SLUMP VALUE
1	0%	24
3	20%	28
5	40%	31

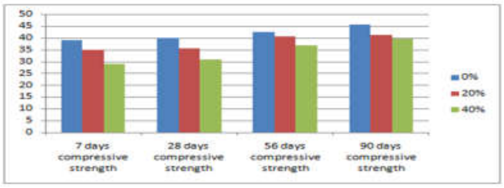
COMPACTION FACTOR TEST

S.no	% Replacement % REPLACEMENT Coarse aggregates by brick bats	Compaction factor
1	0%	0.92
3	20%	0.91
5	40%	0.89



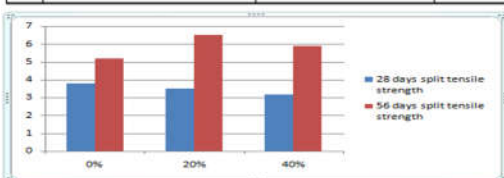
COMPRESSIVE STRENGTH

S.no	%replacement of coarse aggregates by brick bats	7 days compressive strength	28 days compressive strength	56 days compressive strength	90 days compressive strength
1	0%	39	39.8	42.5	45.6
3	20%	34.8	35.6	40.5	41.26
5	40%	29	30.8	36.8	39.5



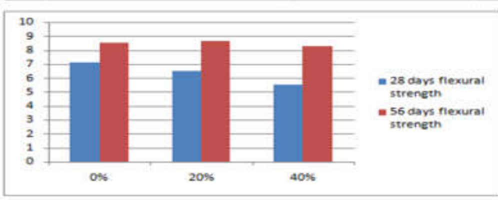
FLEXURAL STRENGTH

S.no	%replacement of coarse aggregates by brick bats	28 days split tensile `strength	56 days split tensile strength
1	0%	3.8	5.2
3	20%	3.5	6.5
5	40%	3.16	5.9



SPIT TENSILE STRENGTH

S.no	%replacement of coarse aggregates by brick bats	28 days flexural strength	56 days flexural strength
1	0%	7.1	8.5
3	20%	6.5	8.65
5	40%	5.5	8.3



V.CONCLUSIONS

From the above experimental program the following conclusions are made

1. The material properties of the cement, fine aggregates and coarse aggregates are within the acceptable limits as per IS code recommendations so we will use the materials for research.
2. Slump cone value for the metakaolin and Nano silica concrete decreases with increasing in the percentage of metakaolin and Nano silica so the concrete was workable up to 15 %.
3. Compaction factor value of metakaolin and Nano silica concrete decreases with increase in the percentage of Nano silica.
4. The result of compressive strength of concrete is maximum at 15% replacement of metakaolin and Nano silica due to excess silica leads to shrinkage of concrete. If silica replacement is low i.e lower than 15% of replacement of nano silica leads to less bonding of concrete.
5. The compressive strength of concrete is the optimum value for 7days curing and 28days curing.
6. Split tensile strength for the cylindrical specimens is maximum at 20% of replacement of metakaolin and Nano silica for 28days curing.
7. The flexural strength of metakaolin and Nano silica concrete is also maximum at 25% replacement of Nano silica for 28 days of curing.
8. In durability test, the metakaolin and nano silica concrete containing 15% of nano silica exhibits better resistance against acid attack, alkaline attack and sulphate stack test for 90 days of curing.
9. The durability of concrete result shows higher resistance in alkaline test compared to acid test and sulphate attack test.

So the replacement of 15% of metakaolin and nano silica is generally useful for better strength values in M30 and M40 grade of concrete.

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