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An Experimental Study on Metakaolin on the Performance of High Strength Concrete as a Partial Replacement to Cement

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ABSTRACT

The most generally utilized material for building is concrete. Attributable to the way that 1990 yield of concrete outcomes in a great deal of ecological outflows since it includes the arrival of CO2 carbon, the worldwide creation of concrete has aggregated considerably.In late years, extra concrete elective materials, for example, silicon oxide gases, fly debris, slag, Rice Husk Ash and Metakaolin have been utilized as concrete elective material for expanding HSC with improved usefulness, energy and life span with decreased permeability.From the most recent examination works misusing Metakaolin, metakaolin is a dehydroxylated aluminum silicate, it is obvious that it is a completely profitable pozzolanic fabric and supplements the force boundaries of cement correctly.The popular development in concrete is that of high generally execution concrete (HPC). It is profoundly respected and is utilized in numerous esteemed ventures, for example, atomic force projects, flyovers, multi-story homes, and so forth.

Exploration on the fractional replacement of concrete with metakaolin as a totally uncommon portion of HPC for M80 Integrate Grade is finished in this theory report. Metakaolin had replacement levels of 0%, 5%, 10%, 15%, and 20 percent (utilizing weight). The discoveries acquired are diverged from conventional examples (compressive strength, split rigidity, flexural strength, sturdiness).

KEY WORDS: Concrete, Metakaolin, High performance concrete.

INTRODUCTION

Rising nations are buying more Portland concrete. Carbonic corrosive gas is mostly used to make Portland concrete. This is because concrete assembly uses petroleum derivatives and electricity. Pozzolanas are used to make concrete, which reduces solid usage and increases the strength and durability of buildings. Metakaolin, once employed as a partial concrete trade material, combines with Ca(OH)2 and solid association items to form C-S-H gel, which provides strength. Metakaolin is made from warm porcelain mud. This will contribute to the construction's water misfortune, allowing its design to be understood. 600 to 750°C is needed for warm reciprocal actuation. Metakaolin is used to strengthen filled cement. Metakaolin reduces cement's sensitivity to gases and moisture. Metakaolin as a part-substitute for portland concrete can't completely limit carbon dioxide emissions.

Regular Battle Betons, High Field Betons, and Ultra High Fight Betons are examined (UHSC). HSC differs from traditional containers, which are shifted by texture components and overall amount. Besides the basic ingredients for normal solid, it contains high-range water reducer (HRWR) and more establishing material (SCM). In recent years, pozzolanic materials have been used as concrete replacements to improve HSC functioning, energy, and toughness despite silicone dioxide, slag, rice husk debris, and metakaolin smoke. Metakaolin, a novel substance in the solids industry, increases strength, reduces salt attack, and reduces air evasion. Metakaolin-replaced concrete may lose some strength. The concrete example's strength will help address this major flaw (MC).

MC in concrete glue or mortar improves the solid's hold on the support. It's vital to connect concrete and metal support bars and special fortifications, since concrete is sometimes reinforced and the support will generally hold its weight. The strength of the cement-to-support connection depends on the design's heap and the support surface. By reducing solid concrete material, concrete construction would reduce ozone-depleting substance emissions. It's solid. According to artistic research, the metakaolin substitution's small energy loss is worrisome. This study measures metakaolin and methylcellulose's energy characteristics.

LITERATURE SURVEY

Sabir.B.B. (2001) He witnessed Metakaolin used as a pozzolanic for mortar and concrete and noted its widespread use in construction. Metakaolin as a pozzolana would create early force and expand long-haul power, they said. Metakaolin modifies the pore design of concrete glue mortar and concrete, protecting it from water and damaging particles that degrade the network.

Ding, Jian-Tong (2002) From this, consider the impact of Metakaolin and Silica Fume on Concrete. Exploratory assessment of seven strong blends of 0, 5, 10, and 15% was done with a mass substitute of cement with crazy reactivity Metakaolin or Silica, with a water solid extent of 0.35 and a sand-to-add up extent of 40%. Metakaolin or Silica affects concrete's convenience, strength, shrinkage, and chloride resistance. Metakaolin and Silica gas breakers are used to limit free drying shrinkage and controlled shrinkage breaking width. Metakaolin or Silica can reduce chloride dispersion in concrete. Silica produces more smoke than Metakaolin.

et al (2004) Estimated Metakaolin's effect on concrete. Over-the-counter concrete was made by combining Metakaolin with concrete or sand by 10% or 20% by weight. Metakaolin Beton's power was turned into a yield factor evaluation (alright expense). Poor Greek Metakaolin and well-off Metakaolin both boost strength. Cement was more stable than sand. As Metakaolin solidified, its beneficial effect on strong force came after 2 days, whereas sand took 90 days. Both Metakaolin displayed ridiculously low k-values (around 0.0 at 28 days) and are portrayed as responsive pozzolanic materials that could boost yield and profitability.

Justice.J.M. (2005) He assessed the cement by replacing 8% of it with Metakaolin and Silica smoke. Metakaolin has also shown to be significant, achieving better grounded properties and added strength in concrete than usual mixtures. Better Metakaolin improved household strength more than coarser Metakaolin. Metakaolin boosted plasticizer use. Metakaolin's shrinkage, lifespan, and strength views changed.

Al-Akhras, M. (2005) This test compares concrete with Metakaolin to determine sulphate resistance. Three solid Metakaolin replacements (5, 10 and 15% by weight) were done with a water solid extent between 0.5 and 0.6. After the allotted time, the models were submerged in 5% sodium sulphate for 18 months. Metakaolin's solidification improves concrete's sulphate resistance. Metakaolin with 0.5 water solids had better sulphate versatility than 0.6. Autoclaved models were more sulfate-resistant than wet ones.

et al (2008) High-energy concrete and mortar models containing varied amounts of Metakaolin (MK) and Fly trash were tested for chloride vulnerability. Each concrete and mortar mix was heated to 200, 400, 600, and 800°C. MK was 5-10-20% of concrete, while Fly Ash was 20-40-60%. Metakaolin and Fly trash constituted 20% of the mortar. Every strong model tested has 85 MPa compressive strength. Concrete and mortar have a low chloride molecule deterrence at normal temperatures. Metacaolin blends were less chloride-vulnerable than Fly and Portland solid mixes. At common temperatures, mortar models were more chloride-permeable than strong models. Over 200°C and 400°C, mortar is more chloride permeable than concrete, and its vulnerability to strong chloride is greater than at normal temperatures.

Jiping Bai et al (2009) This study used arithmetic to predict the strength of Portland solid, Fly flotsam and jetsam, and Metakaolin from exploratory consistency tests. Pozzolanic Compounds, including Fly Ash and Metakaolin Replacement Tiers, had a 40-50% effect. Unprecedented suit plans have consistency models. Using the specified parameters, the saw test records were settled with stunning consistency. It revealed that the models were accurate and could be used to predict Portland solid Fly garbage Metakaolin mixtures.

Eva Vejmelkova (2010) Over-execution concrete (HPC) with metacaolin has unwavering restrictions, including mechanical properties, break mechanical housing, strength ascribes, water regulated, warm, and chloride confining characteristics. Test results reveal that replacing Portland concrete with 10 percent Metakaolin when in question improves or may not affect the HPC's large properties. Basic body houses and warmth transport and limit homes are like normal HPCs. Mechanical and break mechanical homes have been improved, water and water seethe movement limits have been reduced, ice impediment has improved, and security from de-icing salts has been found to be worse but still meets the rules. The 10 percent Metakaolin block in purified water and HCl is greater than Portland concrete.

Khater et al (2010) This examines the exploration office's appraisal of mortar models containing 0%, 5%, 10%, 15%, 20%, 25%, and 30% magnesium chloride. High metabolic replacement models offer better magnesium flexibility. Due to less calcium hydroxide and more C–S–H in the solid, Metakaolin is resistant to powerful chloride reaction by the osmosis of transported lime, avoiding Friedel's salt. Models with 25% metacaoline blended solid mortars improved compressive energy the most. All Metakaolin mortar versions were 1.4-2 gm/cm3.

Torgal Pacheco.F (2011) The evaluation chose Metakaolin and Fly garbage's effect on strength. Water ingestion, oxygen vulnerability, and metropolis resistance helped resolve the power. They argued that substituting 30% fly trash for Portland cement reduces early age compressive energy similarly to 100% Portland concrete. 15 percent Fly flotsam and jetsam and 15 percent Metakaolin based mixes initially lost strength but increased goodness.

et al (2011)

Fly trash, Iron Oxide, and Metakaolin were used as solid trimmings in a group of sums. Using these mineral blends with OPC solid, five powerful combos were created to measure the compressive strength of 3D structures for 3, 7, 14, 28 and 56 days. OPC substituted up to 42% with metakaolin made 40.67 N/mm2 at a solid extent of 0.40 to 0.55, giving up 25.47 N/mm2 on day 56. They found they could make low-effort concrete by replacing 42% of the cement with fly ash (30%), metakaolin (10%), and iron oxide (2 percent).

Muthupriya.P (2011) This explores the tests High Performance Reinforced Concrete Column (HPRC) uses to identify pieces for vital applications. World-class concrete is made by mixing Portland cement, Metakaolin, and fly ash. Explore strength, delicacy, and generosity revelations. Metakaolin and Fly flotsam and jetsam trade standard is 7.5%. They advised that concrete with 7.5% Metakaolin have 12% more compressive strength than usual.

Kannan et al (2012)This study compared Rice husk waste, Metakaolin, and their mixtures as a solid blending part. Body houses, engineered properties, time invested, compressive energy, and splashing water digestion were inspected. 20.9% for 15% for Rice husk trash, 17.42% for 25% for Metakaolin, and 24.61% for 30% for Rice husk trash for Metakaolin (1:1 ratio). WaterBinder extent was 25% for Rice husk flotsam and jetsam, 37.5% for Metakaolin and 39.5% for osmosis of soaked water, and 40% for Rice husk waste for Metakaolin (1:1 extent).

Murali.G and Sruthee (2012) In this study, Metakaolin was likely used as a concrete fragment. Metakaolin beats energy formations in concrete. The best substitution rate is 7.5%. Metakaolin increased concrete's compressive energy by 14.2%, flexibility by 7.9%, and flexicurity by 9.3%.

H.Paiva et al (2012) Exploratory studies showed that Metakaolin diminished usefulness and that HRWRA was essential to get the desired stoop. HRWRA deflocculated Metakaolin garbage and Metakaolin particles dispersed. The study found that using HRWRA in concrete containing a lot of waste, such as Metakaolin, improved dispersion and strength.

Erhan Guneyisi et al. (2012) assessed the sufficiency of metakaolin (MK) and silica smoke (SF) in world-class concrete. Mechanical housing for compressive and flexible cutoff are sought. Metakaolin and Silica exhaust in concrete were tested for water ingestion and gas permeability. The exploratory results showed an improvement in the compressive rockin' rollers of got strong and the mind-boggling blend with unique water solid extents.

et al (2012) Concrete's silica smoke and metakaolin mix. Silica smoke and Metakaolin joined at 6% and 15% (by weight) respectively. Seventh, fourteenth, and 28th day models were delivered. 28-day compressive strong force with Metakaolin in Silica smoke. Seventh-day concrete compressive force decreased with an increase in Metakaolin for Silica smoke content.

Dojkov.I and others (2013) Metakaolin-Ca(OH)2-water and Fly trash Ca(OH)2-water react. Metakaolin added a disproportionate amount of lime during the mitigating period (up to 7 days). The hydration of the solid stages would limit the early season reaction speed of Portland concrete, metacaolin concrete, and solid mortars. Fly flotsam and jetsam Ca(OH)2-water reacts slowly compared to Metakaolin-Ca(OH)2-water. Exploratory findings supported the normal combined use of Metakaolin-Fly Portland concrete in the strong business.

HIGH PERFORMANCE CONCRETE (HPC)

Cement is a common building material. In the stock of a water/concrete (w/c) or water/cover first level plasticizer, it has been found that, in addition to better strength, concrete with low proportions of w/c or w/b also tested various movement properties. This improves HPC. HPC reflects the solid revamp. It's used in atomic force missions, flyovers, multi-story residences, and more.

Since the 1990s, HPC's improvement work has been popular. HPC is now used globally. In 1993, the American Concrete Institute (ACI) described HPC as a solid that meets specified performance and consistency standards that can't be reliably met by using the most productive ordinary substances and hammering, mixing, and relieving practises. Mineral admixture to solidify has largely increased the solid area, considering esteem reserves, power reserves, ecological security, and source preservation. Natural concerns, such as damage caused by uncovering raw materials and carbon dioxide contamination during concrete preparation, have prompted the introduction of more materials to limit concrete use.

Fly debris, rice husk debris, metakaolin, silica smoke, etc. are employed to support HPC combinations. They support both skill and budget. These mixes increase long-term HPC production by reducing porosity and increasing life span. Such materials could increase HPC constructions' energy and lifespan.

METAKAOLIN

Cement is a popular building material. It's best as a replacement for water, as six billion tonnes are produced annually. This is because many uncooked materials are useful for building concrete. Hippies have, with each expression of mischief caused by staple and carbon dioxide outflows during concrete assembly, pushed researchers to limit concrete use by using more chemicals with a fractional alternative to cement. These objects may be gifts, corporate garbage, or low-energy products. Critical decay of solid structures contributes to this severe issue.

To address these worries and other normal incites connected to the expulsion of hazardous waste outcomes in light of financial benefits, Portland cement and Pozzolans are widely employed in concrete mixing.

Originally, pozzolan referred to volcanic soot and calcined earths that react with lime in water. Finely segregated siliceous aluminium can react with hydrated oxide Ca(OH)2 to produce building material heightens. This definition includes fly rubbish, rice husk flotsam and jetsam, and silica smoke (SF).

Portland concrete, whether hydrous or not, includes calcium hydrate (CH), which can reduce strength. The complete removal (or midway reduction) of (CH) with pozzolan results in more stable and uniform cement. Due of these creative focuses over the years, the lounge chair syllable, SF, and water conditioner have become common in concrete. The share of global business for things having pozzolanic qualities exceeds their high level of use, and it is generally agreed that their use can expand with a greater understanding of the natural benefits of such use. This will boost air quality and property values.

Due to conflicting factors, the closeness unit will expand the solid change demonstration with waste side-effects and created pozzolanic compounds. Calcined earth is a pozzolan. Normal pozzolans made from calcined earths and lime have been used for a time.

Metakaolin (MK) calcined earth is used as a pozzolanic additive to mortar and cement. Most of this premium revolves around CH, which is created by cement and has negative energy. Abatement of CH makes concrete and mortars salt-resistant and reduces gastric settling agent oxide responses. This inspires the comprehensive that results from CH's reaction to MK's request.

Low-temperature oxidation of high-quality soil produces MK (6500C-8000C). MK oxide and corundum react with CH. The main reasons for using earth-based pozzolans in mortar and concrete are their comfort and durability. Temperature and mud type also affect calcination. Increasing power is possible, especially with conventional strategy. Early force improvement is a blend of filler and strong alliance acceleration. These effects are enhanced by the pozzolanic reaction between MK and the cement's CH.

MK is a mind-blowing pozzolan that improves early strength, not long-term force. MK modifies the pore type in solid paste, mortar, and metropolitan paste, making the mix impermeable to harmful particles and water that causes system rot. Metakaolin and Oxide Fume are more expensive than Portland concrete because of the low temperature required for their production and their direct cost.

Figure 1: Metaokolin

CHEMICAL COMPOSITION OF METAKAOLIN

Chemical system of Metakaolin is $Al_2O_3.2SiO_2.2H_2O$

The following desk suggests the chemical composition of Metakaolin and is just like Portland cement.

Table 1: Chemical Composition Of Metakaolin

Chemicals	Percentage (%)
SiO_2	62.62
Al_2O_3	28.63
Fe_2O_3	1.07
MgO	0.15
CaO	0.06
Na_2O	1.57
K_2O	3.46
TiO_2	0.36
LOI	2.00

Calcium hydroxide is one of the side-effects of concrete hydration response. As concrete is halfway adjusted with Metakaolin, it responds with calcium hydroxide and results in more C-S-H gel. C-S-H gel is the solitary clarification for improving the strength of completely supported concrete and concrete. The compound response is given beneath.

Cement + Water = C-S-H gel + Ca $(OH)_2$

Ca $(OH)_2$ + Metakaolin = C-S-H gel

BENEFITS AND USES OF METAKAOLIN

The following are some benefits of metakaolin

1. Accelerated compressive and flexural strengths.
2. Reduced permeability (which includes chloride permeability)
3. Reduced capability for efflorescence, which takes place when calcium is transported by water to the surface where it combines with carbon dioxide from the surroundings to make calcium carbonate, which precipitates at the floor as a white residue.
4. Increased resistance to chemical attack
5. Increased durability
6. Reduced consequences of alkali-silica reactivity (ASR)
7. Enhanced workability and completing of concrete
8. Reduced shrinkage, because of "particle packing" making concrete denser
9. Improved color by way of lightening the color of concrete making it viable to tint lighter integral coloration.

EXPERIMENTAL PROGRAM

To accomplish the goals examined over, a test program is intended to explore the effect of concrete replacement by Metakaolin on the strength properties of cement. The details of number of blocks to be tested while the experimentation process is given in the below table:

Table 2: No Blocks Required For the Experiment

Sl. No	% Replacement of Metakaolin	Compressive strength of concrete					Split tensile strength of concrete			Flexural strength of concrete		
		7days	14days	28days	56days	90days	28days	56days	90days	28days	56days	90days
1	0.00%	3	3	3	3	3	3	3	3	3	3	3
2	5.00%	3	3	3	3	3	3	3	3	3	3	3
3	10.00%	3	3	3	3	3	3	3	3	3	3	3
4	15.00%	3	3	3	3	3	3	3	3	3	3	3
5	20.00%	3	3	3	3	3	3	3	3	3	3	3
Total		75 cubes					45 cylinders			45 prisms		

In each batch 2 cubes, 2 cylinders and 2 prisms were casted. Totally 75 cubes, 45 cylinders and 45 prisms were casted during entire experimentation.

Shape and Dimensions of the Blocks

The shape and dimensions specified for the blocks for different tests are given below table

Table 3: Shape and Dimensions of Blocks

Type of test	Shape of block	Length(m)	Breadth(m)	Height(m)	Diameter(m)	Volume of block (m^3)
Compressive strength	Cube	0.15	0.15	0.15	--	0.00375
Split tensile strength	Cylinder	--	--	0.30	0.15	0.00530
Flexural strength	Square prism	0.1	0.1	0.7	--	0.00700

MATERIALS

CEMENT:

Concrete is a latch, a substance used in the collecting cycle that bonds and cements and can integrate various things. Most limit crucial wellsprings of cement are used as an issue inside the amassing of mortar in stone work, and of strong that is, a sum of concrete and a mix to shape a tough improvement material.

Figure 2 : Ordinary Portland cement 53 grade

The ordinary Portland cement of 53 assessment is used according to IS: 12269-1987.

Properties of this solid had been attempted and recorded underneath.

Fineness of cement = five%

2. Unequivocal gravity if concrete = 3.02

3. Standard Consistency of cement = 33%

4. Starting setting time = 50mins

5. Last putting time = Not extra than 10 hours.

AGGREGATES:

Advancement complete, or altogether absolute, is a wide class of coarse particulate matter used being developed, including sand, coarseness, beaten soil, slag, reused concrete and geo-fake sums. Aggregates are the most mined things on earth.

COARSE AGGREGATE:

Crushed stone blend of 20mm size is added from nearby quarry. Sums of length more conspicuous than 20mm size are separated by using sieving. Tests are finished which will find the

- Specific gravity = 2.98
- Fineness modulus = 7.5

Figure 3: Coarse Aggregates

FINE AGGREGATE:

Locally open sparkling sand, which isn't appended by a trademark count number, is used. The aftereffect of the sifter evaluation is insisted in Zone-II (in a state of harmony with IS: 383-1970). The assessments are done and the revelations are showed up under

- Specific gravity = 2.3
- Fineness modulus = 3.06

Figure 4: Fine Aggregates

METAKAOLIN

Metakaolin is a dehydroxylated kind of kaolinite mineral mud. Stones that are affluent in kaolinite are known as china earth or kaolin, generally used in the gathering of porcelain. Metakaolin particle size is more humble than solid pellets, anyway not as extraordinary as silica smoke.

Figure 5 : Metakaolin

WATER:

Drinking water can normally be used. This is to ensure that the water is affordable, freed from degradations like suspended solids, regular dependants and separated salts, which can unfairly impact strong homesteads, explicitly the position, cementing, power, life range, pit charge, and various others

ADMIXTURE

To secure the helpfulness of a clean Geopolymer Concrete, Sulphonated napthalene polymer based absolutely extraordinary plasticizer Conplast SP430 resembling a gritty shaded liquid instantly dispersible in water, the use of a superplasticizer makes the measure of water be restricted by up to 30 percent without lessening the usefulness, in the evaluation of a reachable abatement by up to 15 percent because of p. The use of the superplasticizer is cleaned for the production of stream, self-leveling, self-compacting, and for the formation of preposterous strength and prevalent concrete.

Figure 6 : Conplast SP430

RESULTS

MATERIAL PROPERTIES:

CEMENT:

Table 4 : Test results on the cement

Sl.no	Test	Results	IS code used	Acceptable limit
1	Specific gravity of cement	3.160	IS:2386:1963	3 to 3.2
2	Standard consistency of cement	6mm at 34% w/c	IS:4031:1996	w/c ratio 28%-35%
3	Initial and final setting time	45 mins and 10 hours	IS:4031:1988	Minimum 30mins and should not more than 10 hours
4	Fineness of cement	3.00%	IS:4031:1988	<10%

COARSE AGGREGATES:

Table 5 : Test results on coarse aggregates

Sl.no	**Test**	**Results**	**Is code used**	**Acceptable limit**
1	Fineness modulus	6.5	IS:2386:1963	6.0 to 8.0mm
2	Specific gravity	2.90	IS:2386:1963	2 to 3.1mm
3	Porosity	46.83%	IS:2386:1963	Not greater than 100%
4	Voids ratio	0.8855	IS:2386:1963	Any value
5	Bulk density	1.50g/cc	IS:2386:1963	-
6	Aggregate impact value	37.5	IS:2386:1963	Less than 45%
7	Aggregate crushing value	26.6%	IS:2386:1963	Less than 45%

FINE AGGREGATES:

Table 6 : Test results on the fine aggregates

Sl.no	**Test**	**Result**	**Is code used**	**Acceptable limits**
1	Fineness modulus	4.305	IS:2386:1963	Not more than 3.2 mm
2	Specific gravity	2.43	IS:2386:1963	2.0 to 3.1
3	Porosity	36.6%	IS:2386:1963	Not greater than 100%
4	Voids ratio	0.577	IS:2386:1963	Any value
5	Bulk density	1.5424	IS:2386:1963	-
6	Bulking of sand	3.0%	IS:2386:1963	Less than 10%

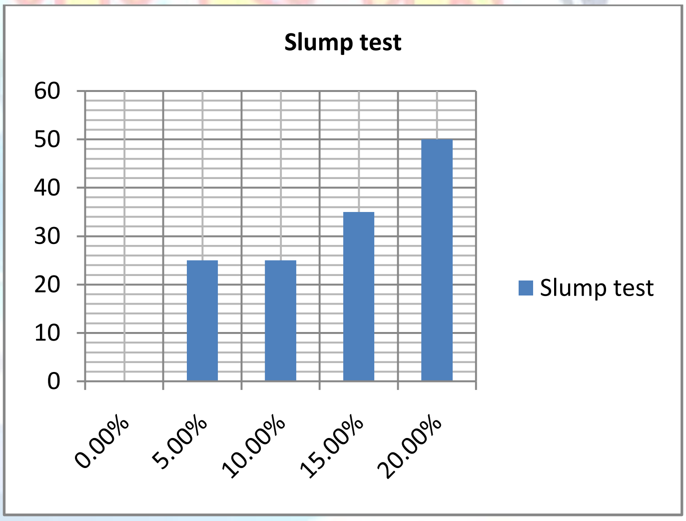
CONCRETE TESTS

TESTS ON FRESH CONCRETE:

1) SLUMP CONE TEST:

Table 7 : Slump Cone Test

S.no	**%Replacement of metakaolin**	**Slump in mm**
1	0.00%	0
2	5.00%	25
3	10.00%	25
4	15.00%	35
5	20.00%	50



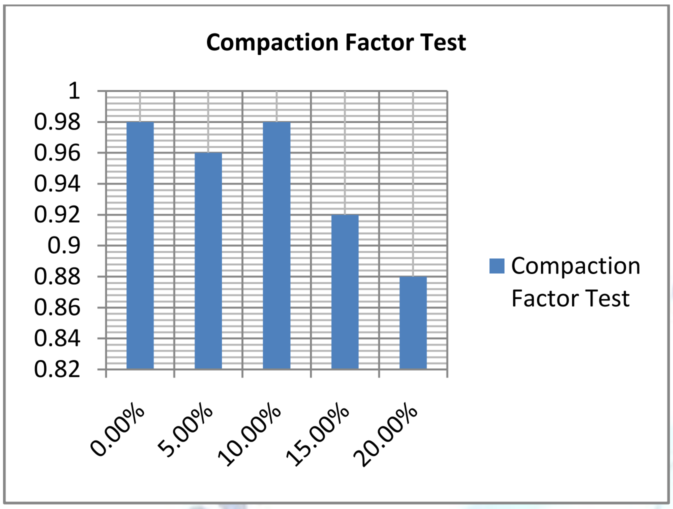
Graph 1 : Slump Cone Test

2) COMPACTION FACTOR TEST

Table 8 : Compaction Factor Test Results

S.no	**%Replacement of metakaolin**	**Compaction factor**
1	0.00%	0.98
2	5.00%	0.96
3	10.00%	0.98
4	15.00%	0.92

5	20.00%	0.88



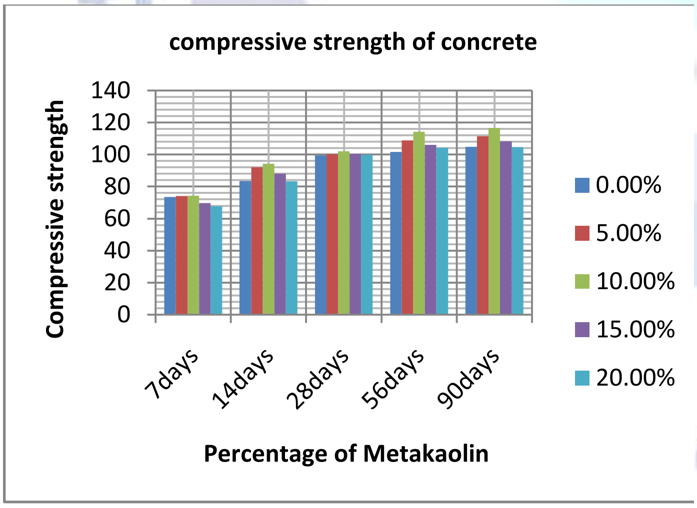
Graph 2 : Compaction Factor Test

TESTS ON HARDENED CONCRETE:

COMPRESSIVE STRENGTH:

Table 9 : Compressive Strength of Concrete

S.no	% Replacement of metakaolin	Compressive strength of concrete				
		7days	14days	28days	56days	90days
1	0.00	73.59	83.52	99.85	101.83	104.96
2	5.00	74.11	92.20	100.39	108.94	111.44
3	10.00	74.44	94.32	102.16	114.41	116.32
4	15.00	69.82	88.20	100.57	106.32	108.52
5	20.00	67.76	83.42	99.74	104.51	104.50

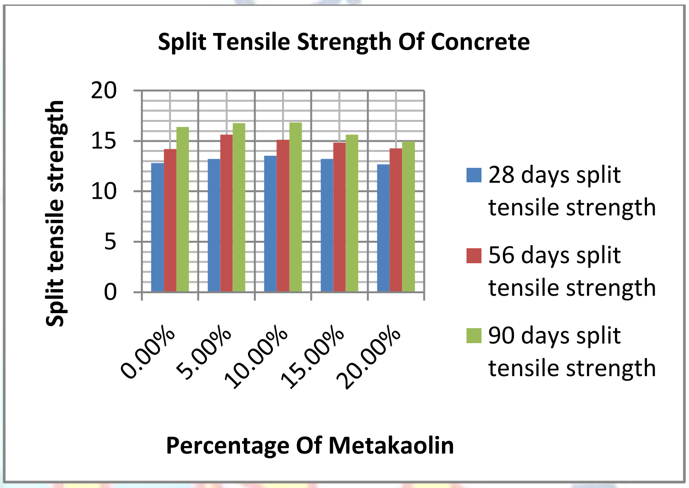


Graph 3 : Compressive Strength of Concrete

SPLIT TENSILE STRENGTH OF CONCRETE:

Table 10 : Split Tensile Strength of Concrete

S.no	% Replacement Of Metakaolin	`Split Tensile Strength Of Concrete		
		28days	56days	90days
1	0.00%	12.92	14.70	16.78
2	5.00%	13.41	15.82	16.86
3	10.00%	13.63	15.32	16.94
4	15.00%	13.43	14.62	15.42
5	20.00%	12.48	14.07	14.26

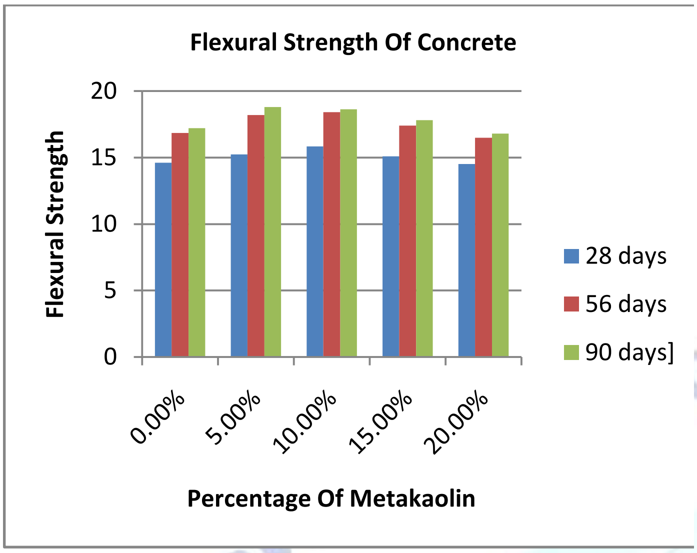


Graph 4 : Split Tensile Strength of Concrete

FLEXURAL STRENGTH:

Table 11 : Flexural Strength of Concrete

S.no	% Replacement Of Metakaolin	`Flexural Strength Of Concrete		
		28days	56days	90days
1	0.00%	14.42	16.54	17.05
2	5.00%	15.34	18.10	18.95
3	10.00%	15.94	18.40	18.44
4	15.00%	14.60	17.10	17.60
5	20.00%	14.42	16.18	16.50



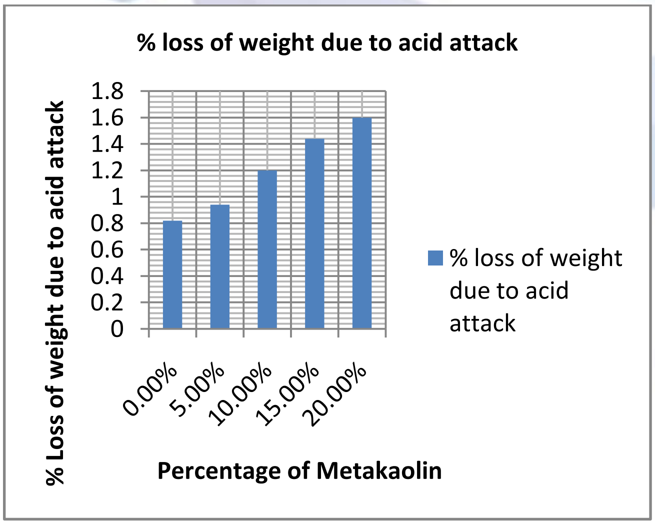
Graph 5 : Flexural Strength of Concrete

DURABILITY

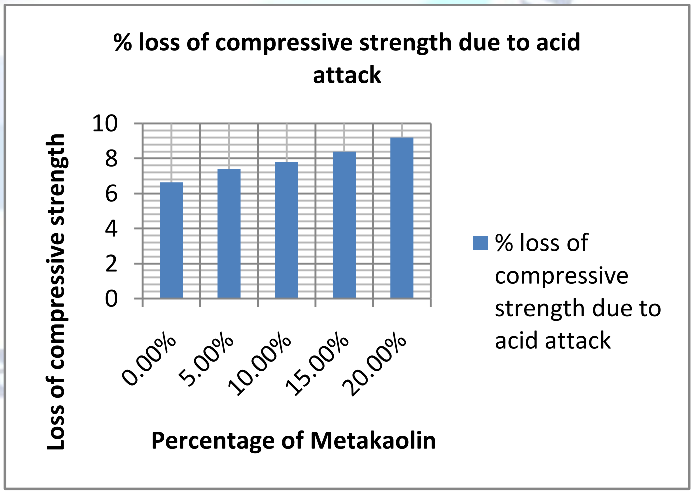
ACID ATTACK

Table 12 : Acid 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 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	0.00%	2261	2242	0.82	99.85	92.94	6.64
2	5.00%	2340	2318	0.94	100.39	92.78	7.40
3	10.00%	2351	2323	1.20	102.16	94.06	7.80
4	15.00%	2234	2202	1.44	100.57	92.03	8.40
5	20.00%	2394	2356	1.60	99.74	90.65	9.20



Graph 6 : Percentage Loss weight due to acid attack

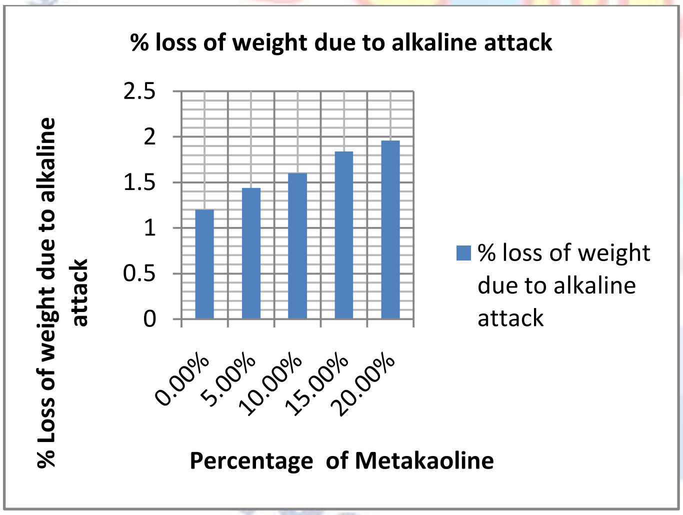


Graph 7 : Percentage Loss of Compressive strength due to acid attack

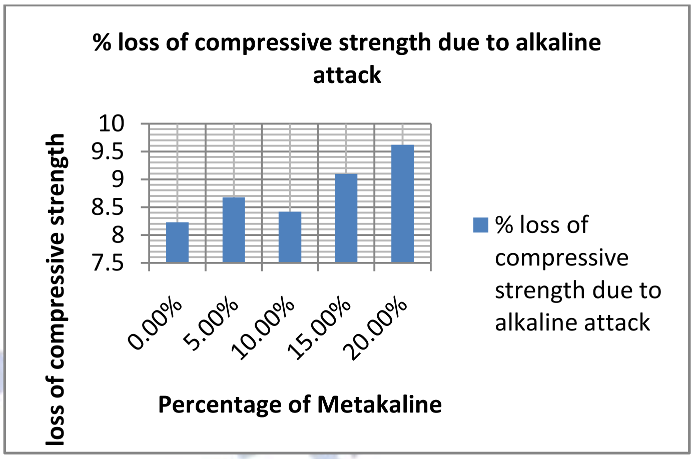
ALKALINE ATTACK

Table 13 : Alkaline Attack Test Results

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	0.00%	2286	2259	1.20	99.55	91.36	8.23
2	5.00%	2340	2306	1.44	100.19	91.50	8.68
3	10.00%	2280	2244	1.60	102.016	93.43	8.42
4	15.00%	2310	2268	1.84	100.47	91.33	9.10
5	20.00%	2296	2251	1.96	99.84	90.24	9.62



Graph 8 : Percentage of weight due to alkaline attack

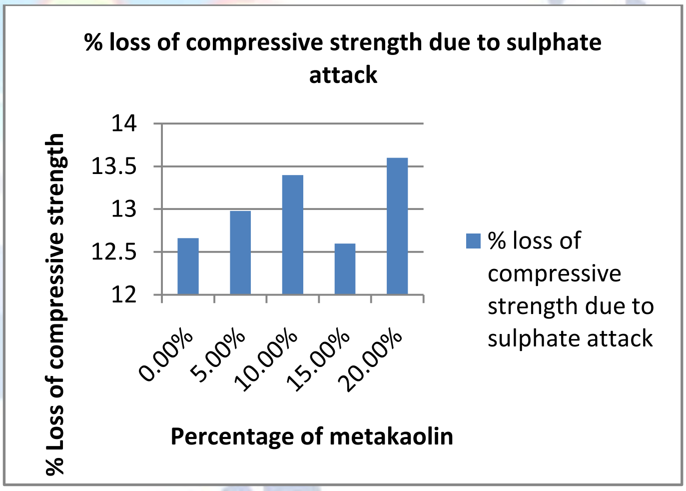


Graph 9 : Percentage loss of Compressive strength due to alkaline attack

SULPHATE ATTACK TEST

Table 14 : 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	0.00%	99.55	86.95	12.66
2	5.00%	100.19	87.18	12.98
3	10.00%	102.016	88.35	13.4
4	15.00%	100.47	87.81	12.6
5	20.00%	99.84	86.26	13.6



Graph 10 : Percentage loss of compressive strength due to sulphate attack

6. CONCLUSION

Of the above exploratory program, the accompanying discoveries were made.

1.As per IS code proposals, the material properties of the concrete, fine totals and coarse totals are inside as far as possible, so we can utilize the materials for research.

2.As the level of metakaolin builds, the droop cone an incentive for the metakaolin solid increments, so the solid was not functional.

3.The compaction factor estimation of metakaolin solid decays as the measure of metakaolin increments, and the greatest compaction factor esteem was seen at 10% of metakaolin.

4.The compressive strength of cement is most elevated at 10% of metakaolin which is the ideal advantage for restoring for 7 days, relieving for 28 days, restoring for 56 days, relieving for 90 days.For cylindrical samples, split tensile strength is optimum at 10 percent of metakaolin for 28 days of curing, 56 days of curing, 90 days of curing.

1. The flexural strength is also optimum for 28 days of curing, 56 days of curing, 90 days of curing, at 10 percent of metakaolin.
2. In all cases, the percentage loss of weight and percentage loss of compressive strength increases as the percentage increases in durability studies of metakaolin concrete. So, up to 10 percent substitution is durable with the metakaolin concrete.

For improved strength values in concrete grade M80, substitution of 10 percent of metakaolin is also usually useful.

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

References

[1] Sabir B.B, Wild S, Bai J, "Metakaolin and calcined clay as pozzolans for concrete :a review" Cement and concrete composite 23 ,(2001),pp.441-454.

[2] Jian-Tong Ding and Zongjin Li "Effects of Metakaolin and Silica Fume on Properties of Concrete" ACI Materials Journal/July-August 2002,pp.393-398.

[3] Badogiannis E, Papadakis V.G., Chaniotakis E, Tsivilis S, "Exploitation of poor Greek kaolins: Strength development of metakaolin concrete and evaluation by means of k-value" Cement and Concrete Research 34 (2004),pp.1035–1041.

[4] Justice J.M, Kennison L.H, Mohr B.J., Beckwith S.L, McCormick L.E, Wiggins B., Zhang Z.Z, and Kurtis K.E, "Comparison of Two Metakaolins and a Silica Fume Used as Supplementary Cementitious Materials" SP- 228(Volume1&2) Seventh International Symposium on Utilization of High-Strength/High Performance Concrete, June(2005),SP228-17.

[5] Nabil M. Al-Akhras "Durability of metakaolin concrete to sulfate attack" Cement and Concrete Research 36 (2006),pp.1727–1734.

[6] Abid Nadeem Johnny Y N Mok, Salman Azhar, Brian H Y Leung, Gary K W Tse "Comparison of chloride permeability of metakaolin and fly ash concretes and mortars under elevated temperatures"33rd conference on our world in concrete &structures,Singapore: 25-27August2008,http://cipremier.com/100033057.

[7] Jiping Bai, AlbinasGailius "Consistency of fly ash and metakaolin concrete" journal of civil engineering and management 15(2):(2009),pp.131–135.

[8] Chao Li, Henghu Sun, Longtu Li "A review: The comparison between alkali-activated slag (Si+Ca) and metakaolin (Si+Al) cements" Cement and Concrete Research 40 (2010),pp.1341–1349.

[9] EvaVejmelkova, Milena Pavlikova, Martin Keppert, ZbynekKeršner, PavlaRovnanikova, Michal Ondracek, Martin Sedlmajer, Robert Cerny "High performance concrete with Czech metakaolin: Experimental analysis of strength, toughness and durability characteristics" Construction and Building Materials 24 (2010),pp. 1404–1411.

[10] Hisham M. Khater "Influence of metakaolin on resistivity of cement mortar to magnesium chloride solution" Ceramics – Silikáty 54 (4),(2010),pp.325-333.

[11] Pacheco Torgal F, Arman Shasavandi, Said Jalali "Using metakaolin to improve the compressive strength and the durability of fly ash based concrete" Invaco2: International seminar, innovation & valorization in civil engineering & construction materials,Rabat-Morocco, 23-25 November(2011), ISBN 987-9954-30-595-9.

[12] Hemant Chauhan "Effect of Activated Flyash in Metakaolin based cement" National Conference on Recent Trends in Engineering & Technology 13-14 May 2011, BVM Engineering College, Gujarat, India .

[13] MuthupriyaP,Subramanian K, Vishnuram B.G, "Investigation on behavior of high performance reinforced concrete columns with metakaolin and fly ash as admixture" International Journal of Advanced Engineering Technology IJAET/Vol.II/ Issue I/January-March (2011),pp.190-202.

[14] Kannan V, Ganesan K, "Strength and water absorption properties of ternary blended cement mortar using rice husk ash and metakaolin" Scholarly Journal of Engineering Research Vol. 1(4),August 2012, pp. 51-59.

[15] Murali G, Sruthee P, "Experimental study of concrete with metakaolin as partial replacement of cement" International journal emerging trends in engineering and development, Issue 2 vol 4(May 2012),ISSN 2249-6149,pp.344-348

[16] Paiva H, Velosa.A , Cachim.P, Ferreira.V.M " Effect of metakaolin dispersion on the fresh and hardened state properties of concrete" Cement and Concrete Research 42 (2012) 607–612.

[17] Erhan Guneyisi, Mehmet Gesoglu, Seda Karaoglu, KasımMermerdas "Strength, permeability and shrinkage cracking of silica fume and metakaolin concretes" Construction and Building Materials 34, (2012) 120–130. [

[18] ikas Srivastava, Rakesh Kumar, Agarwal V.C, Mehta P. K "Effect of Silica Fume and Metakaolin combination on concrete" International journal of civil and structural engineering ,Volume 2, No 3, 2012, ISSN 0976 – 4399,pp. 893-900.

[19] Dojkov I, Stoyanov S, Ninov J, Petrov B, "On the consumption of lime by metakaolin, fly ash and kaoline in model systems" Journal of Chemical Technology and Metallurgy, 48, 2013,pp. 54-60