

Characteristics of High Performance Concrete Using Metakaolin

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ABSTRACT: Concrete is that the most normally used material for construction. The global production of cement has substantially collected on account that 1990. Production of cement results in plenty of environmental pollution because it includes the emission of CO₂ gas. Supplementary cementitious materials like silicon oxide fumes, fly ash, slag, Rice Husk Ash and Metakaolin are utilized in recent years as cement alternative material for growing HSC with progressed workability, energy and durability with decreased permeability. Metakaolin is a dehydroxylated aluminium silicate from the recent analysis works exploitation Metakaolin, it's glaring that it is a completely effective pozzolanic cloth and it correctly complements the power parameters of concrete. High overall performance concrete (HPC) is that the trendy improvement in concrete. It is emerge as highly regarded and is getting used in several prestigious projects such as Nuclear strength projects, flyovers, multi-storied homes.

In this thesis paper, research on partial substitute of cement with metakaolin as completely extraordinary share in HPC for M80 Grade of integrate is completed. The replacement levels had been 0%, 5%, 10%, 15%, and 20% (by using weight) for Metakaolin. The end result obtained (compressive strength, split tensile power, flexural strength, Durability) are compared with the ordinary specimens.

KEYWORDS: Concrete, Metakaolin, High performance concrete.

I. INTRODUCTION

The call for Portland cement is growing dramatically in growing countries. Portland cement manufacturing is one of the main reasons for carbonic acid gas emissions into surroundings. It is due to the usage of fossil fuels, as well as the fuels had to get power at some stage in cement producing method. The usage of pozzolanas for growing concrete is taken under consideration budget friendly, because it lets in the reduction of the cement intake while growing the strength and sturdiness houses of the concrete. Metakaolin once used as a partial replacement substance for cement in concrete, it reacts with Ca (OH)₂ one in all of the with the aid of products of affiliation reaction of cement and leads to further C-S-H gel which ends in amassed electricity. Metakaolin is acquired by thermal activation of porcelain clay. This activation can motive a good sized loss of water in its constitution causing a transcription of its structure. To get companion degree good enough thermal activation, the temperature vary ought to be hooked up between 600 to 750°C. Metakaolin is hired in properly cementing to enhance the compressive and flexural strength of the hardened cement. Metakaolin moreover reduces the hardened cement permeableness to drinks and gases. Thence by way of component substitution Portland cement with Metakaolin no longer totally reduces dioxide emissions however additionally will boom the carrier life of buildings

HIGH PERFORMANCE CONCRETE (HPC)

Concrete might be the maximum appreciably used production cloth within the world. However, when the excessive variety water reducer or first rate plasticizer became invented and began for use to lower the water/cement (w/c) or water/binder (w/b) ratios instead of being completely used as fluid modifiers for normal-strength concretes, it was

International Journal of Innovative Research in Science, Engineering and Technology

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found that in addition to improvement in power, concretes with very low w/c or w/b ratios also tested different progressed traits, along with better fluidity, higher elastic modulus, better flexural electricity, decrease permeability, progressed abrasion resistance, and better sturdiness. This fact brought about the improvement of HPC. HPC is the brand new improvement in concrete. It has turn out to be greater famous nowadays and is getting used in lots of prestigious projects which includes Nuclear strength tasks, flyovers, multistoried homes and many others.

Since Nineteen Nineties, HPC has come to be very famous in production works. At gift, using HPC has spread during the world. In 1993, the American Concrete Institute (ACI) published a wide definition for HPC and is described because the concrete which meets special performance and uniformity requirements that cannot continually be accomplished through the usage of most effective the traditional substances and mixing, putting and curing practices. The addition of mineral admixture in cement has dramatically accelerated along side the development of concrete industry, because of the consideration of value saving, electricity saving, environmental safety and conservation of sources. However, environmental concerns both in terms of damage as a result of the extraction of uncooked material and carbon dioxide emission at some stage in cement manufacture have brought pressures to reduce cement consumption with the aid of using supplementary materials.

METAKAOLIN:

Concrete might be the most significantly used construction cloth inside the world. It is most effective subsequent to water because the most heavily consumed substance and concerning six billion tones being created as soon as a year. This is because of availability of huge amount of uncooked materials handy for cement manufacture. However, environmentalists problem every in phrases of harm because of the extraction of staple and carbon dioxide emission throughout cement manufacture have introduced pressures on researchers for the discount of cement consumption with the aid of partial alternative of cement by using supplementary substances. These materials could also be gift, commercial wastes or by merchandise that want comparatively less electricity to manufacture. The contrary troubles conducive to those pressures area unit the incidents regarding severe deterioration of concrete structures.

In addressing these issues and alternative environmental troubles concerning the disposal of waste industrial via products as a consequence of economic advantages, mixtures of Portland cement and pozzolans location unit currently extraordinarily commonly applied in concrete production.

Originally the term pozzolan turned into related to naturally fashioned volcanic ashes and calcined earths, that react with lime at near temperatures within the presence of water. The admixtures inside the type of silicious aluminous substances that, in finely divided type and within the presence of water, can react with chemical compounds with hydrated oxide $\text{Ca}(\text{OH})_2$ to make compounds that possess constructing cloth residences. This generalized definition covers waste products like Fly ash (FA), Rice husk ash and silica fume (SF).

II. BENEFITS AND USES OF METAKAOLIN

BENEFITS

The following are some benefits of metakaolin

- ✚ Accelerated compressive and flexural strengths.
- ✚ Reduced permeability (which includes chloride permeability)
- ✚ 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.
- ✚ Increased resistance to chemical attack
- ✚ Increased durability
- ✚ Reduced consequences of alkali-silica reactivity (ASR)
- ✚ Enhanced workability and completing of concrete
- ✚ Reduced shrinkage, because of "particle packing" making concrete denser
- ✚ Improved color by way of lightening the color of concrete making it viable to tint lighter integral coloration.

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Vol. 6, Issue 8, August 2017

USES OF METAKAOLIN

The following are a few makes use of of metakaolin

- ✚ High performance, excessive power, and light-weight concrete
- ✚ Precast and poured-mold concrete
- ✚ Fiber cement and Ferro cement products
- ✚ Glass fiber bolstered concrete
- ✚ Countertops, artwork sculptures (see as an instance the unfastened-standing sculptures of Albert Vrana)
- ✚ Mortar and stucco

III. LITERATURE REVIEW

Sabir.B.B et al (2001) done a observe at the utilization of Metakaolin as pozzolanic material for mortar and concrete and noted approximately the extensive variety application of Metakaolin in construction enterprise .They mentioned that the usage of Metakaolin as a pozzolana will assist in the development of early power and a few improvement in long term electricity. They mentioned that Metakaolin alters the pore structure in cement paste mortar and concrete and greatly improves its resistance to transportation of water and diffusion of dangerous ions which cause the degradation of the matrix.

Jian-Tong Ding et al (2002) from this have a look at experimentally discovered out the effects of Metakaolin and Silica Fume on the residences of Concrete. Experimental investigation with seven concrete combinations of zero, five, 10, and 15% with the aid of mass alternative of cement with excessive-reactivity Metakaolin or Silica fume, at a water cement ratio of 0.35 and a sand-to-aggregate ratio of 40% became accomplished. The effect of Metakaolin or Silica fume at the workability, power, shrinkage, and resistance to chloride penetration of concrete was investigated. The incorporation of both Metakaolin and Silica fume in concrete changed into determined to lessen the free drying shrinkage and restrained shrinkage cracking width. It is also mentioned that the incorporation of Metakaolin or Silica fume in concrete can reduce the chloride diffusion fee extensively. The performance of Silica fume became located to be better than Metakaolin.

Badogiannis.E et al (2004) evaluated the effect of Metakaolin on concrete. Eight blend proportions were used to provide excessive-overall performance concrete, in which Metakaolin changed both cement or sand of 10% or 20% by weight of the manage cement content. The strength development of Metakaolin concrete turned into evaluated the use of the performance element (ok fee). With regard to strength improvement the bad Greek Metakaolin and commercially obtained Metakaolin yielded the equal results. The replacement with cement gave better outcomes than that of sand. When Metakaolin changed cement, its positive impact on concrete electricity generally commenced after 2 days where as in case of sand it began handiest after 90 days. Both Metakaolin exhibited very excessive k-values (near to a few.Zero at 28 days) and are characterized as fantastically reactive pozzolanic materials that could lead to concrete manufacturing with remarkable overall performance.

Justice.J.M et al (2005) made a comparative examine by using replacing 8% by way of weight of cement with Metakaolin and Silica fume. Metakaolin addition proved to be useful, ensuing in concrete with substantially better strengths and extra sturdiness than the regular mixes. The use of finer Metakaolin was greater effective in enhancing concrete residences than the coarser Metakaolin. Addition of Metakaolin accelerated the usage of incredible plasticizers. Addition of Metakaolin exhibited enhancements in shrinkage, durability and different power aspects.

IV. MATERIALS

CEMENT:

Cement is a binder, a substance utilized in production that units and hardens and can bind other materials together. The maximum vital forms of cement are used as a issue inside the production of mortar in masonry, and of concrete- that is a aggregate of cement and an mixture to form a sturdy building material.

The normal Portland cement of 53 grade is used in accordance with IS: 12269-1987.

Properties of this cement had been tested and listed below.

1. Fineness of cement = five%
2. Specific gravity if cement = 3.02

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3. Standard Consistency of cement = 33%
4. Initial placing time = 50mins
5. Final putting time = Not extra than 10 hours.

AGGREGATES:

Construction aggregate, or absolutely "aggregate", is a huge class of coarse particulate fabric used in production, including sand, gravel, beaten stone, slag, recycled concrete and geo-artificial aggregates. Aggregates are the most mined materials within the world.

COARSE AGGREGATE:

Crushed stone mixture of 20mm size is added from nearby quarry. Aggregates of length greater than 20mm size are separated by using sieving. Tests are carried which will find out the

- Specific gravity = 2.98
- Fineness modulus = 7.5



Figure: Coarse Aggregates

FINE AGGREGATE:

Locally available sparkling sand, unfastened from natural count number is used. The result of sieve evaluation confirms it to Zone-II (in step with IS: 383-1970). The tests are carried out and results are shown below.

- Specific gravity = 2.3
- Fineness modulus = 3.06



Fine Aggregates

METAKAOLIN

Metakaolin is a dehydroxylated form of the clay mineral kaolinite. Stone that are wealthy in kaolinite are known as china clay or kaolin, historically used inside the manufacture of porcelain. The particle size of metakaolin is smaller than cement particles, however not as best as silica fume.



Metakaolin

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WATER:

Generally potable water ought to be used. This is to make sure that the water is cheap unfastened from such impurities as suspended solids, organic depend and dissolved salts, which may additionally adversely affect the residences of the concrete, especially the placing, hardening, energy, sturdiness, pit fee, and many others.

ADMIXTURE

To acquire workability of clean Geopolymer Concrete, Sulphonated naphthalene polymer based totally wonderful plasticizer Complast SP430 in the shape of a brown liquid right away dispersible in water, Use of super plasticizer lets in the discount of water to the quantity up to 30 percentage without lowering the workability, in assessment to the feasible reduction up to fifteen percentage in case of plasticizers. The use of super plasticizer is practiced for production of flowing, self leveling, self compacting, and for production of excessive strength and high performance concrete.



Figure: Complast SP430

TEST TO BE PERFORMED ON THE SPECIMENS:

COMPRESSIVE STRENGTH

- 7 days specimens age
- 14 days specimens age
- 28 days specimens age
- 56 days specimens age
- 90 days specimens age

SPLIT TENSILE STRENGTH OF SPECIMENS

- 28 days specimens age
- 56 days specimens age
- 90 days specimens age

FLEXURAL STRENGTH OF SPECIMENS

- 28 days specimens' age
- 56 days specimens' age
- 90 days specimens' age

DURABILITY

- 90 days specimens' age

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V. RESULTS AND ANALYSIS

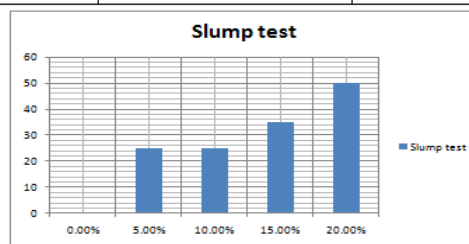
CONCRETE TESTS

A. TESTS ON FRESH CONCRETE:

SLUMP CONE TEST:

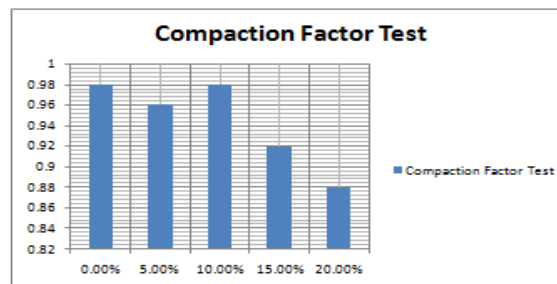
Table: Slump Cone Test

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



COMPACTION FACTOR TEST

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



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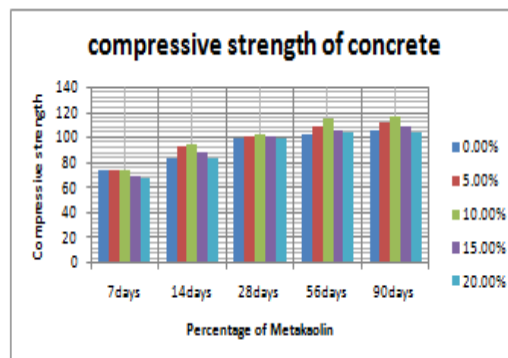
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TESTS ON HARDENED CONCRETE:

1. COMPRESSIVE STRENGTH:

Table: Compressive Strength of Concrete

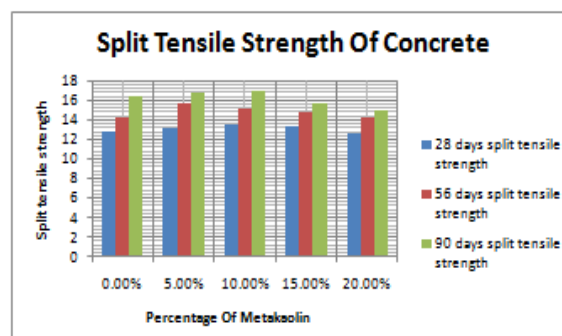
S. no	% Replacement of Metakaolin	Compressive strength of concrete				
		7days	14days	28days	56days	90days
1	0.00	73.49	83.42	99.55	101.73	104.86
2	5.00	74.01	92.10	100.19	108.84	111.54
3	10.00	74.34	94.22	102.016	114.31	116.62
4	15.00	69.72	88.10	100.47	106.12	108.22
5	20.00	67.66	83.22	99.84	104.31	104.60



SPLIT TENSILE STRENGTH OF CONCRETE:

Table: Split Tensile Strength of Concrete

S. no	% Replacement Of Metakaolin	Split Tensile Strength Of Concrete		
		28days	56days	90days
1	0.00%	12.82	14.20	16.38
2	5.00%	13.21	15.62	16.76
3	10.00%	13.53	15.12	16.84
4	15.00%	13.23	14.82	15.62
5	20.00%	12.68	14.27	14.96



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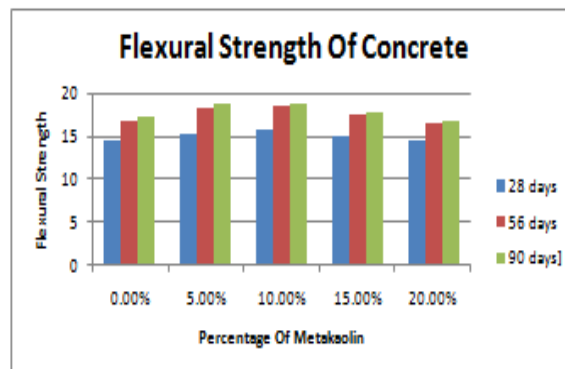
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1. FLEXURAL STRENGTH:

S. no	% Replacement Of Metakaolin	Flexural Strength Of Concrete		
		28days	56days	90days
1	0.00%	14.62	16.84	17.20
2	5.00%	15.24	18.20	18.80
3	10.00%	15.84	18.40	18.64
4	15.00%	15.10	17.40	17.80
5	20.00%	14.52	16.48	16.80



DURABILITY

1. ACID ATTACK

Table: Acid Attack

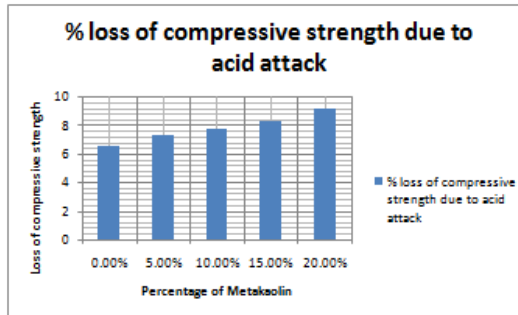
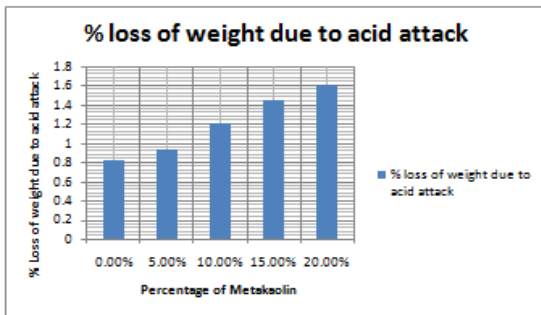
Sl. No	% replacement	Initial weight of cube after 28days curing in grams	Final weight of cubes after 90days curing in grams	% loss of weight due to acid attack	Compressive strength of cube after 28days curing	Compressive strength of cubes after 90days curing	% loss of compressive strength due to acid attack
1	0.00%	2261	2242	0.82	99.55	92.94	6.64
2	5.00%	2340	2318	0.94	100.19	92.78	7.40
3	10.00%	2351	2323	1.20	102.016	94.06	7.80
4	15.00%	2234	2202	1.44	100.47	92.03	8.40
5	20.00%	2394	2356	1.60	99.84	90.65	9.20

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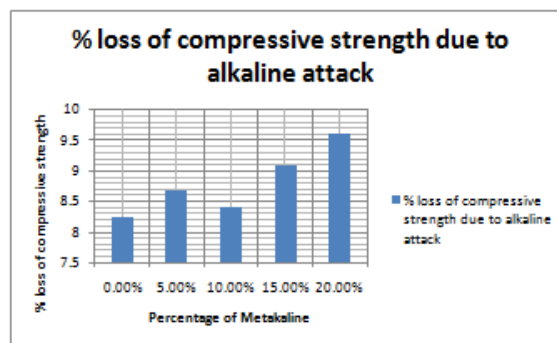
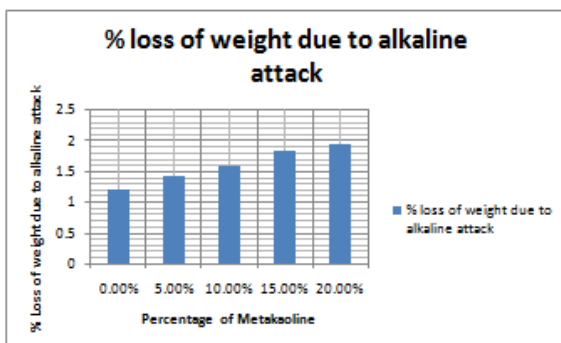
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ALKALINE ATTACK

Table: 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



SULPHATE ATTACK TEST

Table: Sulphate Attack Test

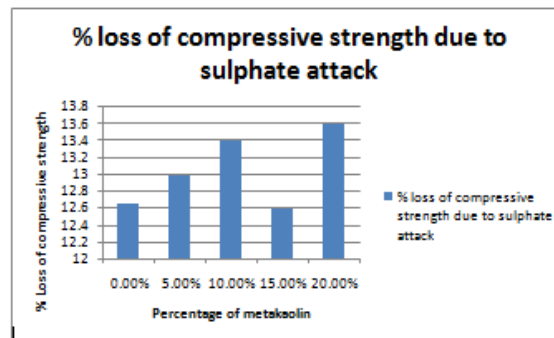
Sl. No	% replacement	Compressive strength of cube after 28days curing	Compressive strength of cubes after 90days curing	% loss of compressive strength due to sulphate attack
1	0.00%	99.55	86.95	12.66
2	5.00%	100.19	87.18	12.98
3	10.00%	102.016	88.35	13.4
4	15.00%	100.47	87.81	12.6
5	20.00%	99.84	86.26	13.6

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VI. CONCLUSIONS

From the above experimental program the following conclusions were 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 concrete increases with increasing in the percentage of Metakaolin so the concrete was not workable.
3. Compaction factor value of Metakaolin concrete decreases with increase in the percentage of Metakaolin and the maximum values of compaction factor was observed at 10% of Metakaolin.
4. The compressive strength of concrete is maximum at 10% of Metakaolin and is the optimum value for 7days curing, 28days curing, 56days curing, 90days curing.
5. Split tensile strength for the cylindrical specimens is maximum at 10% of metakaolin for 28days curing, 56days is curing, 90days curing.
6. The flexural strength of copper slag concrete is also maximum at 10% of Metakaolin for 28days curing, 56days is curing, 90days curing.
7. The percentage loss of weight and percentage loss of compressive strength is increases with in increasing the percentages in all cases in durability studies in Metakaolin concrete. So, the Metakaolin concrete is durable up to 10% replacement.

So the replacement of 10% of Metakaolin is generally useful for better strength values in M80 grade of concrete.

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