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EFFECT OF PARTIALLY REPLACEMENT CEMENT IN THE CONCRETE MIX USING GGBS, METAKAOLIN AND SILICA FUME

Prof. Kamlesh Kumar Choudhary[1]
Assistant Professor, Department of Civil Engineering, SIET Engineering College, Jabalpur, MP, India
Gaurav Sharma[2]
UG Student (M. Tech.) Department of Civil Engineering, SIET Engineering College, Jabalpur, MP, India

ABSTRACT
In instruction to build more streets, research is needed to identify optional development strategies that will increase the sufficiency of the current budgets. Replacing cement with metakaolin, GGBS, and silica fumes is one such option. Cement is one of the most important materials in concrete because it binds it and provides strength to the concrete. A relatively recent mineral admixture for concrete is called metakaolin. In terms of pozzolanic reactivity, it is comparable to silica fume and GGBS, but costs less. In this work, the effects of metakaolin and silica fume on various concrete properties were examined and contrasted. Concrete was poured with a water/binder ratio of 0.45 and metakaolin, in place of 0, 5, 10,15,20,25 and 30% partially replacement of the cement (by weight of cement). And same ratio 0, 5, 10,15,20,25 and 30% partially replacement of the cement (by weight of cement) one by one GGBS and Silica Fume. In this experiment Supplementary materials Metakaolin, GGBS and Silica Fume in varying percentages i.e. 0% of Metakaolin, 0% of GGBS, and 0% of Silica Fume for normal concrete, 5% of Metakaolin,10% of GGBS, and 15% of Silica Fume for multi blended concrete, 10% of Metakaolin, 15% of GGBS, and 5% of Silica Fume for multi blended concrete, 15% of Metakaolin,5% of GGBS, and 10% of Silica Fume for multi blended concrete, of total dosage (i.e.30%) by weight of cement. Results are taken as a Beams and Cubes are casted to check the flexural strength and compressive of concrete at 14 days and 28 days.

Keywords:
Metakaolin, GGBS, Silica Fume, Cement, Workability, Compressive Strength and Tensile Strength.

INTRODUCTION

The Concrete is composed principally of aggregates, a Portland or blended cement, and water, and may contain other cementitious materials and/or chemical admixtures. It will contain some amount of entrapped air and may also contain purposely entrained air obtained by use of an admixture or air-entraining cement. Chemical admixtures are frequently used to accelerate, retard, improve workability, reduce mixing water requirements, increase strength, or alter other properties of the concrete. The framework needs of our nation are expanding step by step and with concrete being a fundamental constituent of development material in a huge bit of this infra-underlying framework, it is important to upgrade its qualities through strength and solidness. Concrete is a moderately fragile material. Expansion of strands to substantial makes it a more pliable material. Plain concrete cement has a few weaknesses like low elasticity, restricted liability, little protection from breaking, high fragility, and helpless sturdiness. Exploratory examinations have shown that strands improve the mechanical properties of cement, for example, flexural strength, compressive strength, rigidity, creep conduct, sway opposition, and sturdiness. Among them, polymer filaments and steel strands appreciate prevalent in the area of cement.
The workability of binary mix containing higher percentage substitution with Metakaolin, GGBS and Silica Fume was higher and lower respectively. Improvement of properties can be observed for mixes designed appropriately. Long term compressive strength of Metakaolin, GGBS and Silica Fume mixes can be improved. Addition of varied percentage of fibres made with steel to the optimum percentage of compressive & flexural tensile strength as 15% & 27% respectively. Concrete was poured with a water/binder ratio of 0.45 and metakaolin, in place of 0, 5, 10,15,20,25 and 30% partially replacement of the cement (by weight of cement).

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OBJECTIVES

Following are objectives of the study.

1. To find out the effect of Metakaolin, GGBS and silica fume on strength when mixed with concrete sample.
2. To study the workability of concrete on variation in different percentage of Metakaolin, GGBS and silica fume when mixed with concrete.
3. To find the compressive strength and flexural strength all through 7 and 28 Days.
4. To Increase the economy of the construction with using the cheaper material Metakaolin, GGBS and silica fume as a replacement of the cement.
5. To reduce the maintenance cost of concrete.

METHODOLOGY

To fulfill our study, we adopted the research methodology are as follows:
We performed compressive, flexural strength test to find out the increase in strength of concrete. To find the optimum value of the fiber added percentage we have read out many of the research papers. The cubes and beams are casted for finding out the strength of conventional concrete and fiber added concrete with M30, grade are as follows

1. To determine the compressive strength test, we had casted the 36 cubes of 100x100x100mm
2. To determine the flexural strength test, we had casted the 36 beams of 500x100x100mm

Test Results of Physical Properties of Cement

Table 1 Test Results of Physical Properties of Cement

Properties	IS Code	Values Obtained	Standard Value
Specific Gravity	IS 4031 (Part 11) - 1988	3.15	-
Fineness	IS 4031 (Part 1) - 1988	5%	<10
Normal Consistency	IS 4031 (Part 4) - 1988	30%	
Compressive Strength	IS 4031 (Part 6) - 1988	38.2 Mpa (7 days)	>37 Mpa
Initial Setting Time	IS 4031 (Part 5) -1988	65 minutes	>30
Final Setting Time	IS 4031 (Part 5) -1988	195 minutes	<600

Test Results of Physical Properties of Fine Aggregate

Table 2 Physical Properties of Fine Aggregate

S. No.	Characteristics	Result
1	Aggregate type	Natural
2	Specific gravity	2.62
3	Fineness modulus	2.74

Test Results of Physical Properties of coarse aggregate

Table 3 Physical properties of 20 mm coarse aggregate

S.No.	Characteristics	Result
1	Aggregate type	Crushed stone
2	Maximum size of aggregate	20
3	Specific gravity	2.71
4	Fineness modulus	2.94

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Test Results of Physical Properties of Silica Fume

Table 4 physical properties of Silica Fume

Particle size	1µm
Bulk density (As-produced) (densified)	 130 to 430 kg/m³. 480to720 kg/m³.
Specific gravity	2.2
Specific surface	15,000 to 30,000 m²/kg

Metakaolin

Metakaolin is an amorphous alumina silicate that is created by subjecting refined kaolin clay to a particular calcination procedure. By interacting with calcium hydroxide to generate additional binding elements, such as calcium silicate hydrate, this mineral additive greatly improves a number of cement-based product qualities, including strength and durability in concrete.

Figure 1 Metakaolin Powder

Key Characteristics of Metakaolin:

1. **Manufacturing Process:**
   Calcining kaolin clay for approximately 12 hours at temperatures between 600- and 800-degrees Celsius yields metakaolin.
2. **Particle Size:**
   Greater surface area for enhanced reactivity due to smaller particle size compared to cement particles.
3. **ASTM C618 Specifications:**
   To be used as a mineral additive in concrete, a material classified as Class N by AASHTO M295-11 must meet ASTM C618 criteria.
4. **Benefits of Concrete with Metakaolin:**
   Strengthens the concrete's flexural and compressive strengths.
5. **Durability:**
   Diminishes alkali-silica reactivity (ASR) effects, efflorescence, permeability, and chemical assault. Enhances concrete workability and finishing while lowering shrinkage.

Mix proportion of Concrete

Table 5 Mix proportion of Concrete

Cement	Water	Fine aggregate	Coarse aggregate
414	186	697.88	1128.06
1	0.45	1.68	2.72

RESULTS AND DISCUSSION

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Table 6 The Final Trial Batches Quantities of Silica Fume, Metakaolin Per Cubic Meter of Concrete M30

Mix Code	Cement kg/m3	silica fume	Metakaolin kg/m3	Fine Aggregate kg/m^3	Coarse Aggregate kg/m^3	Water kg/m	W/ C ratio
M30	414.00	0.00	0.00	697.88	1128.06	161.00	0.45
M-1	331.20	0.00	82.80	697.88	1128.06	161.00	0.45
M-2	331.20	20.70	62.10	697.88	1128.06	161.00	0.45
M-3	331.20	41.40	41.40	697.88	1128.06	161.00	0.45
M-4	331.20	62.10	20.70	697.88	1128.06	161.00	0.45
M-5	331.20	82.80	0.00	697.88	1128.06	161.00	0.45

Compressive Strength of Concrete Cube at 14 & 28 days

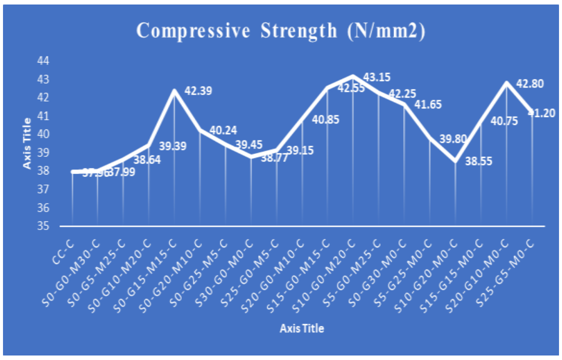
Table 7.2 Compressive Strength at 14 days of Concrete Cube

Mix Code	Compressive strength for cube(N/mm^2)	Increase In %
CC-C	34.52	0.00
S0-G0-M30-C	34.89	1.09
S0-G5-M25-C	35.17	1.90
S0-G10-M20-C	36.75	6.48
S0-G15-M15-C	36.75	6.48
S0-G20-M10-C	38.45	11.40
S0-G25-M5-C	37.52	8.69
S30-G0-M0-C	37.89	9.78
S25-G0-M5-C	37.52	8.69
S20-G0-M10-C	37.89	9.78
S15-G0-M15-C	38.64	11.95
S10-G0-M20-C	**39.02**	**13.04**
S5-G0-M25-C	38.55	11.69
S0-G30-M0-C	37.89	9.78
S5-G25-M0-C	36.75	6.48
S10-G20-M0-C	37.89	9.78
S15-G15-M0-C	38.77	12.33
S20-G10-M0-C	**39.15**	**13.43**
S25-G5-M0-C	38.55	11.69

Table 7.3 Compressive Strength at 28 days of Concrete Cube

Mix Code	Compressive strength for cube(N/mm^2)	Increase In %
CC-C	37.96	0.00
S0-G0-M30-C	37.99	0.08
S0-G5-M25-C	38.64	1.79
S0-G10-M20-C	39.39	3.77
S0-G15-M15-C	42.39	11.67
S0-G20-M10-C	40.24	6.01
S0-G25-M5-C	39.45	3.93
S30-G0-M0-C	38.77	2.13
S25-G0-M5-C	39.15	3.13
S20-G0-M10-C	40.85	7.61
S15-G0-M15-C	42.55	12.09
S10-G0-M20-C	43.15	13.67
S5-G0-M25-C	42.25	11.30
S0-G30-M0-C	41.65	9.72
S5-G25-M0-C	39.80	4.85
S10-G20-M0-C	38.55	1.55
S15-G15-M0-C	40.75	7.35
S20-G10-M0-C	42.80	12.75
S25-G5-M0-C	41.20	8.54

Graph 7.2 Compressive Strength at 14 days of Concrete Cube



Graph 7.3 Compressive Strength at 28 days of Concrete Cube

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CONCLUSION

The following conclusions can be drawn from the experimental investigations conducted on the behavior of concretes by using Metakaolin and silica fume as partial replacements for cement

1. Silica Fume, GGBS and Metakaolin are partially replaced with the cement, the consumption of the cement is reduced and also the cost of construction is reduced.
2. The workability is improved by the partial replacement of the Silica Fume, GGBS and Metakaolin with cement mix concrete.
3. We find that there is increase in the workability of concrete that Slump value Mix Code CC-C is 73 mm for conventional concrete and mix concrete maximum Slump value Mix Code S20-G10-M0-C is 78.00 mm.
4. We find that there is increase in the Compressive strength of concrete that strength value Mix Code CC-C is 34.52 N/mm2 for conventional concrete and mix concrete maximum Compressive strength value Mix Code S20-G10-M0-C is 39.15 N/mm2 with increase 13.43 % at 7 days.
5. We find that there is increase in the Compressive strength of concrete that strength value Mix Code CC-C is 37.96 N/mm2 for conventional concrete and mix concrete maximum Compressive strength value Mix Code S20-G10-M0-C is 42.80 N/mm2 with increase 12.75 % at 28 days.
6. We find that there is increase in the Split tensile strength of concrete that strength value Mix Code CC-Cy is 5.25 N/mm2 for conventional concrete and mix concrete maximum Split tensile strength value Mix Code S20-G10-M0-Cy is 6.45 N/mm2 with increase 22.85 % at 28 days.

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