International Conference on Innovative Research in Engineering, Management and Sciences
International Journal of Scientific Research in Computer Science, Engineering and Information Technology
© 2019 IJSRCSEIT | Volume 4 | Issue 9 | ISSN : 2456-3307

Effect of Replacement of Cement by Fly Ash and Metakaolin on Strength Properties of Concrete

Rajendra T N
Assistant Professor, Department of Civil Engineering, New Horizon College of Engineering, Outer Ring Road, Marathalli, Bengaluru, Karnataka, India

ABSTRACT

An experimental investigation was carried out to understand the effects of partial replacement of cement by fly ash and metakaolin of M50 grade concrete mix. A control specimen was prepared by using OPC 43 grade cement. Improvement in compressive strength and split tensile strength was observed with the replacement of cement by 15% fly ash and metakaolin at 5%, 10%, 15% and 20%. An increase of up to 35.8 % in compressive strength and up to 51.5% split tensile strength was observed.
Keywords : Cement concrete, Metakaolin, Fly ash, Compressive Strength, Split tensile strength.

I. INTRODUCTION

With the development of technology and increased consumption of concrete, betterment of characteristics such as strength, workability, durability of conventional concrete is essential to make it more suitable for various situations.

Fly ash, Metakaolin, Rice husk ash, Silica fume etc used as alternative cementitious ingredients of concrete which are known to enhance the strength properties and make the conventional concrete more suitable under different circumstances and also cost effective.

Use of these alternative materials is also eco-friendly as it reduces emission of CO2.

Also, enhancement in the strength and durability characteristics is one of the important significance of adding fly ash. It is observed from the previous experimental results available in literature that, blending metakaolin with Portland cement improves the properties of concrete by increasing compressive and flexural strength, preventing alkali silica reaction, reducing efflorescence and shrinkage preventing corrosion of steel.

II. METHODS AND MATERIAL

A. Materials

- **Water:** Drinking water was used for the experimental study
- **Cement: cement conforming to IS, OPC of grade 43.** Test results obtained are given in Table 1.
- **Fine aggregates:** River sand with fineness modulus 2.97 conforming to zone II was used. Test results obtained are given in Table 1.
- **Coarse aggregates: aggregates of c**rushed granite with fineness modulus 6.9 (20 mm down size) was used for the experimental study and the results for the tests carried out are presented in table 1
- **Fly ash: F**ly ash with the results tabulated in table 1 used for the study.

- **Metakaolin:** The specific gravity of metakaolin was evaluated from the experimental study. The results have been tabulated in table 1.

Table 1: Specific gravity of materials used

Materials	Specific gravity
Cement	3.14
Fine aggregates	2.60
Coarse aggregates	2.68
Fly ash	2.18
Metakaolin	2.38

Table 2: Mineral Composition of metakaolin

Major Minerals	Percentage (%)
Lime (Cao)	1.1
Silica (SiO_2)	53.2
Alumina (Al_2O_3)	43.0
Iron oxide (Fe_2O_3)	0.98
Magnesium oxide (MgO)	0.08
Sodium oxide (Na_2O)	0.035

B. Mix Proportion

M30 grade of concrete was used. The mix proportion was evaluated confirming to the IS 10262-2009. The various mix proportions for nominal concrete (Control specimen) and fly ash based metakaolin concrete are presented in Table 3.

Table 3 : Mix proportion

Mix Proportion	Cement (Kg/m^3)	Metakaolin (MK) (Kg/m^3)	Fly ash (Kg/m^3)	Fine Aggregate (Kg/m^3)	Coarse Aggregate (Kg/m^3)	W/C
Control specimen	450	.....	.....	865	970	0.4
MK 5% Fly ash 15%	360	22.5	67.5	865	970	0.4
MK 10% Fly ash 15%	337.5	45	67.5	865	970	0.4
MK 15% Fly ash 15%	315	67.5	67.5	865	970	0.4
MK 20% Fly ash 15%	292.5	90	67.5	865	970	0.4

C. Testing of specimen

Standard sized cubes (150 mm X 150 mm) and cylinders (150 mm diameter and 300 mm length) were tested for compressive strength and split tensile strength.

- **Compressive strength**
  Nine cubes were cast for each mix and tested at the age of 3, 7 and 28 days under 200T capacity Compression Testing Machine
- **Split Tensile strength**
  Nine cylinders were cast and tested at the age of 28 days under 200T capacity Compression Testing Machine

III. RESULTS AND DISCUSSION

- **Compressive strength: S**trength values are shown in Table 4 and are also depicted graphically in figure 1

Table 4. Results-Compressive strength

Mix	Compressive strength (N/mm^2)		
	3 days	7 days	28 days
Control specimen	23.75	34.5	58.2
MK 5% Fly ash 15%	24.9	38.75	61
MK 10% Fly ash 15%	28.2	46.5	68.2
MK 15% Fly ash 15%	32.2	51	74.2
MK 20% Fly ash 15%	33.75	55.8	79

- **Split Tensile strength**

The split tensile strength was determined after normal curing of specimens for 28 days and the same are tabulated in Table 5.

Table 5. Results- Split tensile test

Mix	Split Tensile Strength (N/mm²)
Control specimen	2.85
MK 5% Fly ash 15%	3.11
MK 10% Fly ash 15%	3.58
MK 15% Fly ash 15%`	4.12
MK 20% Fly ash 15%	4.32

A considerable increase in the strength was observed from the results (Table 4 and 5).

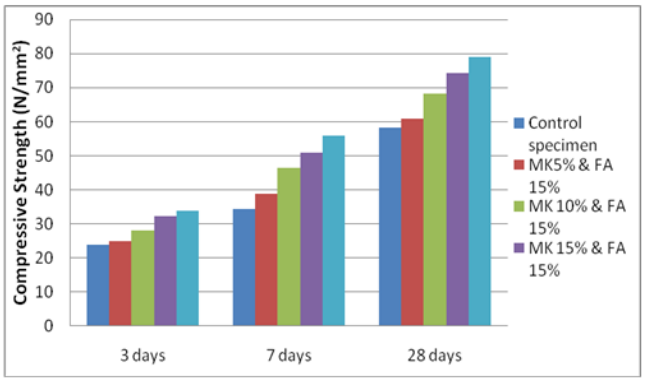

Fig. 1 Variation in Compressive Strength

IV. Conclusions

It can be concluded from the results that,

1. Metakaolin and flyash contributed to enhancement early strength and ultimate strength of concrete.
2. Use of metakaolin and flyash and their lesser cost affects in cheaper economy

V. REFERENCES

[1]. IS 456:2000 Indian Standard, Plain and Reinforced Concrete - Code of Practice, Bureau of Indian Standard, New Delhi 110002.

[2]. IS 10262:2009 Concrete Mix Proportioning Guidelines - Code of Practice, Bureau of Indian Standard, New Delhi 110002.

[3]. 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.

[4]. Nova John, " Strength Properties of Metakaolin Admixed Concrete" IJSRP, volume 3, Issue 6.

[5]. M. Nazeer, R. Arun Kumar, "Strength Studies on Metakaolin Blended High-Volume Fly Ash Concrete", IJEAT-August 2014 Vol. 3, pp-176-179.

[6]. Vikas Srivastava., Rakesh Kumar., Agarwal V.C., "Metakaolin inclusion: Effect on mechanical properties of concrete", J. Acad. Indus. Res. Vol. 1(5), pp. 251-253, October 2012, ISSN: 2278-5213.

[7]. Murali.G., Sruthee P., "Experimental study of concrete with Metakaolin as Partial replacement of cement", International Journal of Emerging trends in Engineering and development, Issue 2, Vol.4, May 2012, ISSN 2249-6149.

[8]. 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.

[9]. Mohammad Azhar, Mohammed Moshin Ali Qureshi, "Strength Development in Concrete by Incorporating Metakaolin" International Journal of Advanced Trends in Computer Science and Engineeering, -2013,Vol.2, pp 634-639.

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