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Effect of Partial Replacement of Cement by Fly Ash and Metakaolin on Concrete Strength with M. Sand as Fine Aggregate

Rajendra T N[1] ,Surendra . B.V[2],

[1] *Assistant Professor, Department of Civil Engineering*
New Horizon college of Engineering, Bengaluru, Karnataka, India 560103

[2]*Associate Professor, Department of Civil Engineering*
New Horizon college of Engineering, Bengaluru, Karnataka, India 560103

Abstract – Due to rapid, worldwide growth in construction, there is a tremendous increase in usage of concrete that has resulted in heavy production of cement and scarcity of river sand. Production of cement leads to environmental pollution due to emission of carbon dioxide (Co_2). Extraction of river sand results into lowering of the water head affecting ground water level. It also leads to erosion of nearby land. The aim of the present investigation is to study the variation in compressive strength and split tensile strength properties by replacing cement partially with fly ash and metakaolin and by using M.Sand in place of river sand. The Experimental study consisting of the concrete specimen containing cement 15% with metakalin and fly ash at 5%, 10%, 15% and 20% and using M.Sand as fine aggregates has been carried out. The results indicated that there was an improvement in the strength properties.

Key Words: Cement concrete, Metakaolin, Fly ash, M.Sand Compressive Strength, Split tensile strength.

1. INTRODUCTION

The demand for concrete is next only to water. With the advancement of technology and increased field of application of concrete and mortars, various properties of the ordinary concrete needed modification to make it more suitable for various situations, economical and eco friendly.

This has led to the use of cementitious materials such as fly ash, silica fume, metakaolin etc. which have contributed towards higher performance, energy conservation and economy.

The use of fly ash and metakaolin partially replacing the cement in concrete results in reduction of cement used, reduction in the emission of carbon dioxide (Co_2), conservation of existing resources along with the enhancement in the strength and durability properties of concrete.

Depletion of natural sand deposits in our country is already causing serious threat to the environment as well as society. This along with shortage in natural good quality sand has made researchers to look for an alternative to river sand. The M.sand produced under controlled and well supervised conditions can a better substitute for river sand. In use of fly ash for partially replacing the Portland cement in concrete not only reduces the amount of cement used, but also significantly enhances the properties of concrete, reduces the emission of CO_2, conserves the existing resources and greatly improves consistency [3]. The addition of fly ash in concrete improves certain properties such as workability, later age strength development and a few durability characteristics [3].

Blending metakaolin with Portland cement improves the properties of concrete by increasing compressive and flexural strength, providing resistance to chemical attack, reducing permeability substantially preventing alkali silica reaction, reducing efflorescence and shrinkage preventing corrosion of steel [1].

2. MATERIALS AND METHODS

2.1. Materials

2.1.1 Cement: OPC 43- grade confirming to Indian Standards is used in the present study and the test is conducted to determine specific gravity. The results have been tabulated in table2.1.

2.1.2 Fine aggregates: River sand with fineness modulus 3.1 conforming to zone II was used for the experimental study and specific gravity is determined. The results have been tabulated in table 1.

2.1.3 Coarse aggregates: Crushed granite with fineness modulus 7.1 having size between 20 mm and 4.75 mm was used for the experimental study and the tests were conducted to evaluate specific gravity. The results have been tabulated in table 2. 1.

2.1.4 Water: Drinking water was used for the experimental study

2.1.5 Fly ash: The specific gravity of fly ash was evaluated for the experimental study. The results have been tabulated in table 1.

2.1.6 Metakaolin: The specific gravity of metakaolin was evaluated for the experimental study. The results have been tabulated in table 2.1.

Table 2.1: Significant properties of materials used

Materials	Specific gravity
Cement	3.12
Fine aggregates	2.62
Coarse aggregates	2.68
Fly ash	2.23
Metakaolin	2.4

Table 2.2: Mineral Composition of metakaolin

Major Minerals	Percentage
Lime (Cao)	1.2
Silica (SiO_2)	51.92
Alumina (Al_2O_3)	42.0
Iron oxide (Fe_2O_3)	0.93
Magnesium oxide (MgO)	0.06
Sodium oxide (Na_2O)	0.04

2.2 Mix Proportion

For the present study M40 grade of concrete was used. The mix proportion was evaluated confirming to the IS 10262-2009. The various mix proportions for conventional concrete (Control specimen) and fly ash based metakaolin concrete (by partially replacing OPC with fly ash and metakaolin) are presented in Table2.3.

Table 2.3: M40 Mix proportion

Mix Proportion	Cement content (Kg/m^3)	Metakaolin (MK) (Kg/m^3)	Fly ash (Kg/m^3)	F.A (Kg/m^3)	C.A (Kg/m^3)	W/C
Control specimen	492	…….	…….	673	1080	0.4
MK 5% Fly ash 15%	393.6	73.8	24.6	673	1080	0.4
MK 10% Fly ash 15%	369	73.8	49.2	673	1080	0.4
MK 15% Fly ash 15%	344.4	73.8	73.8	673	1080	0.4
MK 20% Fly ash 15%	319.8	73.8	98.4	673	1080	0.4

3. Experimental Program

3.1 Specimen

The experimental program consisted of casting and testing of M40 grade concrete specimens of cube (150 mm) and cylinder (150 X 300 mm).

3.2 Compressive strength

Nine numbers of cubes were cast for each mix and tested using 200T capacity Compression Testing Machine (CTM).

3.3 Split Tensile strength

Nine numbers of cylinders were cast and tested using 200T capacity Compression Testing Machine (CTM).

4. Results and discussions

4.1 Compressive strength:

The compressive strength was determined after normal curing for 3days, 7 days and 28 days. The results are presented in Table 4.1 and are also depicted graphically in figure 4.1.

Table 4.1 Compressive Strength Test results

specifications	Compressive strength (N/mm^2)		
	3 days	7 days	28 days
Control specimen	18.5	29	44.5
Fly ash 5% MK 15%	20	32	47
Fly ash 10% MK 15%	22	35	53
Fly ash 15% MK 15%	27	39	61
Fly ash 15% MK 20%	29	45	66

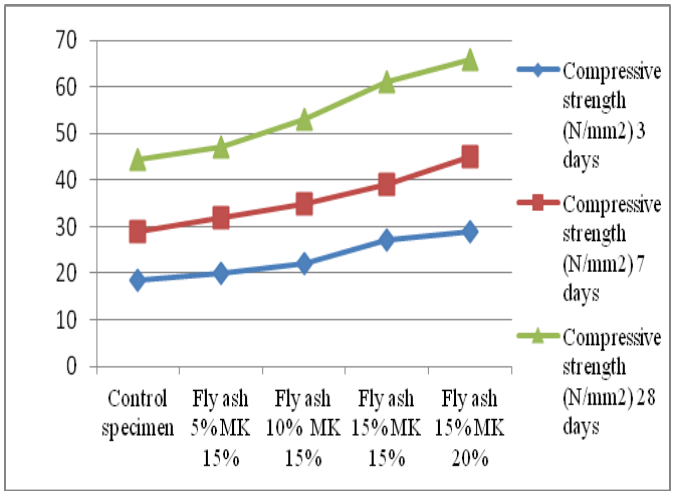

Fig. 4.1 Compressive strength test results

4.2 Split Tensile strength

The split tensile strength was determined after normal curing for 28 days. The results are presented in Table 4.2.

Table 4.2 Split tensile test results

Specifications	Split Tensile Strength (N/mm²)
Control specimen	2.61
MK 5% Fly ash 15%	2.78
MK 10% Fly ash 15%	3.18
MK 15% Fly ash 15%	3.65
MK 20% Fly ash 15%	3.87

The results indicate that there is a substantial increase in the compressive strength with the increase in % of Metakaolin replacing cement.

5. Conclusions

The present study led to the following conclusions.

1. Addition of Metakaolin and flyash has resulted in enhanced early strength and ultimate strength of concrete.
2. The reduction in the Emission of green gases is a major benefit from environment sustainability point of view.
3. the cost reduction can be achieved due to the easy availability of metakaolin and fly ash.

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