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Evaluation of Strength of Plain Cement Concrete with Partial Replacement of Cement by Meta Kaolin & Fly Ash

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***Abstract*—The present report deals with the effects of mineral admixtures, by partial replacement of cement, in terms of improved performance on compressive and flexural strengths. Experimental work was carried out to investigate the effect of Meta kaolin and Fly ash by partial replacing cement and keeping same water cement ratio to ordinary concrete & meta kaolin and fly ash. In this program we are going to construct 48 cube samples of size 150mmx150mmx150mm for different percentages of Meta kaolin and Fly ash with partial replacement of cement will casted and tested. The concrete mixes had 0%,5%,10%,15% of Fly ash and Meta Kaolin, replacing cement partially, so as to determine the best proportion, which would give maximum compressive strength. Beam specimens will casted and tested for their flexural strength. The dimensions of each beam will 750mmx150mmx150mm.The beams were tested on universal testing machine to verify their flexural strength after 7days, 28 days of curing with single point load. The results will compare with the beams of varying flexural strength of Plain Cement Concrete, Plain Cement Concrete with Meta kaolin & Fly ash.**

Keywords—Compressive Stength; Flexural Strength; Metakaolin; Fly ash;Flue Ash;High Reactive Metakaolin

I. INTRODUCTION

Recent report aimed at energy conversation in the cement and concrete industry has in part, focused on the use of less energy intensive materials such as Fly ash, Slag and Silica Fume. Lately some attention has been given to the use of Natural Pozzolans like Meta kaolin as a possible partial replacement for cement. Amongst the various methods used to improve the durability of concrete, and to achieve high performance concrete, the use of Meta kaolin is a relatively new approach. Meta kaolin, or heat-treated clay, may be used as a Supplementary Cementations Material in concrete to reduce cement consumption, to increase strength. Meta kaolin reduces the porosity of concrete. Plain concrete possesses a very low tensile strength, limited ductility and little resistance to cracking. Concrete is one of the most common material used in the construction industry.

In the past few years, many research and modifications has been done to produce concrete with desired characteristics. Concrete is the most widely used and versatile building material having high compressive strength, by additions of some Pozzolanic materials, the various properties of concrete wiz, workability, durability ,strength, resistance to cracks and permeability can be improved. The use of Meta kaolin as a partial cement replacements material in mortar and concretes has been studied in recent years, despite of numbers of studies, use of Meta kaolin is still not popular in practice. The use of cement replacing materials fundamental in developing low cost construction materials. Concrete is the most widely used and versatile building material which is generally used to resist compressive forces. By addition of some pozzolanic materials, the various properties of concrete viz., Compressive Strength, Flexural Strength Porosity can be improved.

II. RESEARCH SIGNIFICANCE

The presented research is aimed at studying the properties like optimum percentage of Meta Kaolin and Fly Ash with partial replacement of cement, to determine the optimum concrete mix. The optimum concrete mix is used to determine the compressive, flexural strength. The study also aims at determining the flexural strength of the concrete beams based on the cross sectional dimensions, span and amount of meta kaolin + fly ash used and compared with actual strength obtained based on experimental results. The research findings will help engineers to understand the overall performance of concrete for flexural strength & compressive strength.

III. EXPERIMENTAL PROGRAM AND SETUP

The main aim of this experimentation is to study the effect of partial replacement of cement by Meta kaolin & fly ash on the properties of concrete.

The experimental programme is divided in four phases.

a) Concrete mix design as per IS 10262-2009 for M20 and M25 grade of concrete. Meta Kaolin, Fly Ash after partial replacement of cement with varying percentages.

b) Casting of cubes and beams

c) Curing of cubes and beams for 7 days and 28 days

d) Testing of all beam specimens with single point loading for flexural strength and compressive strength for all cubes.

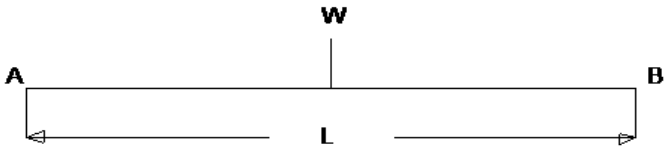

Fig.(a) Point Load Beam

Test Setup And Procedure :

The beam specimen will simply supported with a concentrated load applied at mid span, as shown in figure. Load was applied by using UTM (40 tons capacity) in 40kg increments up to failure load. At each load increment, cracks will inspected and marked, and the beam is photographed. Continuous monitoring will carried out all through the testing. After **7& 28** days curing period, the specimens is taken outside the curing tank and will tested under a compression testing machine of 200 ton capacity for compressive strength. The crushing loads will noted and the average compressive strength of three specimens is determined.

IV. MATERIALS

Meta Kaolin

Considerable research has been done on natural pozzolans, namely on thermally activated ordinary clay and kaolinitic clay. These unpurified materials have often been called " Meta kaolin". Such a product, white or cream in colour, purified, thermally activated is called High Reactive Meta kaolin(HRM).High reactive meta kaolin shows high pozzolanic reactivity and reduction in $Ca(OH)_2$ even as early as one day. It is also observed that the cement paste undergoes distinct densification. The improvement offered by this densification includes an increase in strength and decrease in permeability. The Meta kaolin using as a cement replacement in concrete countertop mixes, instead of other pozzolans such as silica flume, fly ash to:

- Boost compressive strength
- Make finishing easier
- Reduce efflorescence
- Maintain colour, especially in Other Portland Cement

Fly Ash

Fly ash, is also known as flue-ash, it is one of the residues generated in combustion, and comprises the fine particles that rise with the flue gases. In an industrial context, fly ash usually refers to ash produced during combustion of coal. In India, fly ash was used for the first time in construction of Rihand Irrigation Project, Uttar Pradesh in 1962, replacing cement up to about 15%.

ASTM broadly classified fly ash into two classes as

Class F fly ash: Fly ash normally produced by burning anthracite or bituminous coal, usually has been than 5% CaO. Class F fly ash has pozzolanic properties only.

Class C fly ash: Fly ash normally produced by burning lignite or sub-bituminous coal. Some fly ash may have CaO content in excess of 10%. In addition to pozzolanic properties, class C fly ash also possesses cementations properties.

Mix Proportions

Table (1): Mix Proportions for M20 & M25 per m^3

Mix Description	Cement (Kg/m^3)	Sand (Kg/m^3)	Aggregate (Kg/m^3)	Water (Lit.)	MK+FA (Kg/m^3)
M20					
0%	383	735	1103	192	-
5%	363.85	735	1103	192	19.15
10%	344.70	735	1103	192	38.30
15%	325.55	735	1103	192	57.45
M25					
0%	426.66	721.46	1082.18	213	-
5%	405.33	721.46	1082.18	213	21.33
10%	384	721.46	1082.18	213	42.66
15%	362.66	721.46	1082.18	213	64

V. SPECIMEN CASTING

48 cube samples of size 150mmx150mmx150mm for different percentages of MK and FA in partial replacement of cement were casted. The concrete mixes had 0%,5%,10% & 15% of Meta kaolin & Fly Ash with partial replacement of cement. After final setting of cubes, the cube moulds were removed and cubes were kept in water tank for curing up to 7days & 28 days. All 48 beam specimen size 750mmx150mm x150mm were casted with optimum compressive strength for the specific mix in single lift and consolidated using tamping rods. After setting, the beams were kept for curing in water tank. Average of three cubes is taken for compressive strength and average of three beams were taken for flexural strength.

VI. RESULTS AND DISCUSSION

Compressive Strength

The result of compressive strength were plotted in below Table(2) and shown in fig. (b) & fig. (c)

Result indicate that if we increase percentage of meta kaolin and fly ash up to 10-15 % will give us a good results and help to increase compressive strength of concrete.

Table (2) Compressive strength of various types of concrete at different ages

Mix Description	Compressive Strength (N/mm^2)	
	7 Days	28 Days
M20		
0%	14.67	19.11
5%	17.78	19.55
10%	19.11	19.78
15%	19.15	19.85
M25		
0%	17.55	23.75
5%	17.78	24.01
10%	19.55	24.70
15%	19.60	24.71

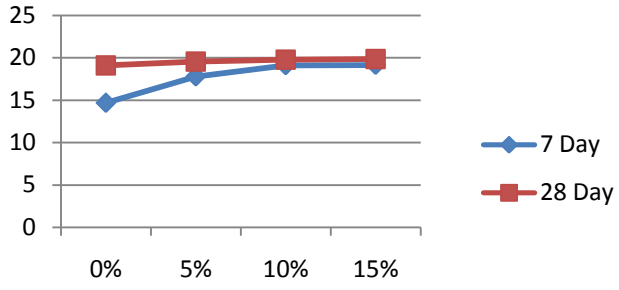

Fig. (b) Compressive Strength for M20 Grade Concrete

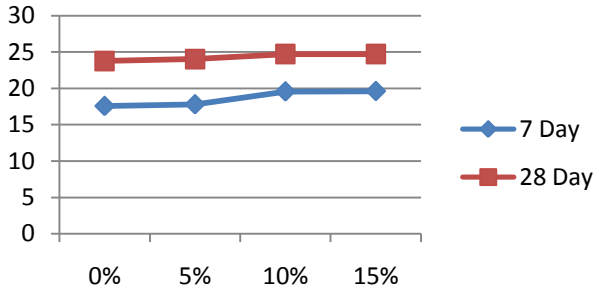

Fig. (c) Compressive Strength for M25 Grade Concrete

Flexural Strength

Table (3) and fig. (d) & fig. (e) Illustrated the values of flexural strength for various types of concrete . Concrete with no replacement means Plain Cement Concrete 0% replacement, 5%, 10% & 15% replacement of meta kaolin and fly ash. Meta kaolin and fly ash mix concretes showed improvement in flexural strength over those of concrete without Meta kaolin and fly ash.

The flexural strength test was determined according to B.S. 1881 : part 118 , 150 x 150 x 750 mm specimens were tested . The flexural strength of the specimens were calculated by the following equation :-

$$Fr = \frac{PL}{bd^2}$$

Where :-

Fr = modulus of rupture , (N/mm^2) .

P = maximum applied load , (N) .

L = span length , (mm) .

b = width of the specimen , (mm) .

d = depth of the specimen , (mm) .

Table (3) Flexural strength of various types of concrete at different ages

Mix Description	Flexural Strength (N/mm^2)	
	7 Days	28 Days
M20		
0%	7.01	7.15
5%	8.91	9.40
10%	9.70	10.16
15%	9.90	10.27
M25		
0%	9.27	9.80
5%	9.78	10.15
10%	10.17	10.25
15%	10.35	10.77

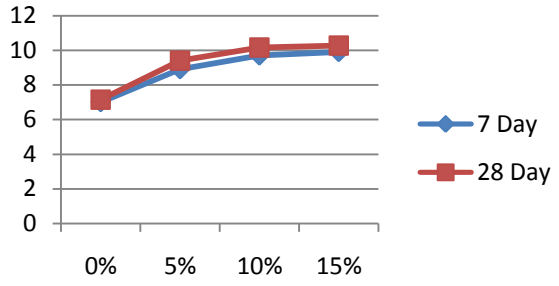

Fig. (d) Flexural Strength for M20 Grade Concrete

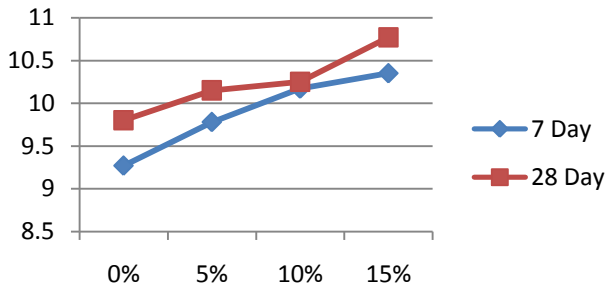

Fig. (e) Flexural Strength for M25 Grade Concrete

VII. CONCLUSION

Plain concrete is a brittle material and fails suddenly. Addition of Meta kaolin & Fly ash to concrete changes its brittle mode of failure into a more ductile one and improves the concrete ductility. The compressive strength and flexural strength of concrete increases with meta kaolin & fly ash content. It is true up to 15% replacement if we replace cement by more than 15% strength starts reducing. Therefore it always preferable to use Meta kaolin & Fly ash with 10% replacement of cement and it gives us better result.

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