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EXPERIMENTAL STUDY ON MECHANICAL PROPERTIES OF CONCRETE BY REPLACING METAKAOLIN AND FLYASH WITH CEMENT

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ABSTRACT :
The most used construction material nowadays is concrete. Need for high strength concrete in the age of such construction boom in India is increasing alot. As high strength concrete is required for heavy structure. Pozzolonic materials are used in concrete can be used as a cementitious material. With appropriate percentage of mix using Flyash and Metakaolin we can reduce the cost of concrete by a significant amount. In this paper concrete specimen were prepared with 0%, 4%, 8%, 12%, 16%, 20% of cement are replaced by Flyash & Metakaolin (equally). Concrete is weak when it undergoes tension but have a good response when it undergoes compression. Total 10mix are to be prepared by changing the proportion by percentage of flyash and metakaolin for M20 and M40 grade. Later Age Strength, Workability and Durability characteristics can be improved by adding flyash and metakaolin. To evaluate properties of concrete with a mix of metakaolin and flyash are prepared with different mix proportion. Main purpose this research is to find the optimum use flyash and metakaolin in place of concrete. Use of flyash and metakaolin is done in 50% each. From the optimization 20% cement replaced by flyash and metakaolin has given positive results.
Keyword: Metakaolin, Flyash, Mixture, supplementary cementitious material (SCM) & Serviceability

1. INTRODUCTION :

In modern construction times, concrete is very important constituent which plays a very important role. Concrete is a material which is composite in nature and has a very high usage in construction. There are many circumstances where we have to optimize the cost issue and also need early day strength for faster construction. Due to which pozzolanic materials are used to enhance the cement properties. Flyash, Metakaolin, Silica dime are pozzolanic material which can be used as cementitious material in place of cement in concrete which will give significant results in the research of concrete for the next few years. We know that the flyash is cheaper as compared to cement but cost of metakaolin compared to cement is higher, so combination of using flyash and metakaolin is adopted keeping in mind about the cost of cement as well as early strength of cement.

2. LITERATURE REVIEW :

Jian Tong Ding (2002) investigated the MK or SK on the workability, strength, shrinkage and resistance to chloride penetration of concrete were investigated and compared in this study. For the given mixture proportions, MK offers better workability than does SF. As the replay\cement level was increased, the strength of the MK – modified concrete increased at all ages. The increase in the strength was similar to that of the SF – modified concrete. The incorporation of the both MK and SF

in concrete can reduce the free drying the free drying shrinkage and restrained shrinkage cracking width. The initial cracking appeared earlier in the SFand MK- in concrete can reduce the chloride diffusion rate significantly, with the SF concrete performing somewhat better. Nova John (2013) investigated the cement replacement levels were 5%,10%,15%,20% by weight for metakaolin. The strength of all metakaolin admixed concrete mixes over shoot the strength development of concrete. Mix with 15% metakaolin is superior to all other mixes. The increase in metakaolin content improves the compressive strength, split tensile strength and flexural strength upto 15% replacement. The result encourages the use of metakaolin, as pozzolanic material for partial cement replacement in producing high strength concrete. The inclusion of metakaolin results in faster early age strength development of concrete. The utilization of supplementary cementitious material like metakaolin concrete can compensate for environmental, technical and economic issues caused by cement production.

Shelorkar ajay (2013) observed that the compressive strength of Metakaolin based HGC increases with the increase in percentage of Metakaolin. The variations of compressive strength of HGC with different Metakaolin content of 4 %, 6 % and 8 %. As the Metakaolin increases from 4% to 8% the compressive strength increases about 9.23 MPa for 4 % Metakaolin, 12.98 MPa for 6 % Metakaolin and 20.87 MPa for 8 % Metakaolin. The increase in compressive strength due to the addition of Metakaolin is due to pozzolanic activity. The compressive strength of HGC increases by 10.13 %, 14.24 % and 22.90% due to addition of Metakaolin content of 4 %, 6 % and 8 % respectively in comparison with control concrete specimens of HGC. The variation of RCPT values in HGC for different proportions of Metakaolin blended concrete. It has been observed that as the percentage of Metakaolin increase the permeability of concrete decreases. Also, it was observed that values of rapid chloride permeability of HGC decrease up to 1450 coulombs, 1548.67 coulombs and 1684.70 coulombs for 4% , 6% and 8% of metakaolin respectively in comparison to control concrete specimens. The percentage reduction in permeability values in coulombs was 48.57 %, 51.88 % and 56.43% for Metakaolin content of 4%, 6% and 8% respectively. Patil (2012) studied the compressive strength of concrete increases with increase in HRM content up to 7.5%. Thereafter there is slight decline in strength for 10%, 12% and 15% due excess amount of HRM which reduces the w/b ratio and delay pozzolanic activity. The higher strength in case of 7.5% addition is due to sufficient amount of HRM available to react with calcium hydroxide which accelerates hydration of cement and forms C-S-H gel. The 7.5% addition of high reactivity metakaolin in cement is the optimum percentage enhancing the compressive strength at 28 days by 7.73% when compared with the control mix specimen. The 7.5% addition of high reactivity metakaolin in cement is enhanced the resistance to chloride attack. The compressive strength of concrete incorporated with 7.5% HRM is reduced only by 3.85% as compared with the reduction of strength of control mix specimen is by 4.88%. The 7.5% addition of high reactivity metakaolin in cement is also enhanced the resistance to sulfate attack. The compressive strength of concrete incorporated with 7.5% HRM is reduced only by 6.01% as compared with the reduction of strength of control mix specimen by 9.29%. The present study deals with the compressive strength, split tensile strength and flexural strength for cement replacement by metakaolin based concrete

1. Experimental Methodology

Experimental work were carried out by replacing cement with flyash and metakaolin with proportion such as 0%, 4%, 8%, 12%, 16% & 20%. Metakaolin and Flyash proportion are distributed equally in

proportion. Mix Design were prepared as per IS 10262-2009 for M20 and M40. OPC of grade 43 is used in preparation of mix design of M20 & M40 grade. Fresh cements is used without having any lumps. Water-Cement ratio adopted from IS 456:2007 is 0.45.

3. Materials and Equipments

a. **Fine Aggregate**

Aggregate size of 4.75mm maximum is used as fine aggregate as per grading zone III as per IS 383 – 1970.

b. ***Coarse Aggregate***

Locally available aggregate are used with a maximum size of 20mm.

c. Flyash

Flyash is the ash type material which is removed from the exhaust gas from burning coal at power plant to generate electricity. Air pollution control equipment is used to extract ash by equipment called electrostatic precipitators before exhaust emitting in the atmosphere through stacks or chimney.

d. ***Metakaolin***

Specific Gravity of 2.4 of Metakaolin from 20 Micron Ltd company were purchased and used as a replacement to cement.

e. Mould

Mould size of 150mm x 150mm x 150mm is used for concrete cube casting.

4. Design Mix Methodology

As per IS 10262-2009 for control concrete mix design are proposed by adoption water cement ratio of 0.45 by replacing cement with Metakaolin in equal proportion from total replacement of cement.

Table 1. Percentage of Replacement for mix design

% of Cement Replacement	Metakaolin% + Flyash %
4	2+2
8	4+4
12	6+6
16	8+8
20	10+10

Compressive Strength

For each mix, twenty three number of cubes of size 150mm were casted for 28days and tested using Compression Testing Machine (CTM). The specimen placed on the platform of the CTM. The load applied gradually until the failure stage. The ultimate load noted and calculated the compressive strength of corresponding specimen.

5. Results

Table 2. Compression Test Result of M20 and M40 on 28th day

Sl No	Cube No	Cement% + FA% +MK%	Compressive Strength N/mm^2 for M20	Compressive Strength N/mm^{2}for M40
1	C1	100+0+0	26.2	44.5

2	C2	100+0+0	26.4	44.1
3	C3	100+0+0	26.0	44.6
4	C4	96+2+2	26.94	45.2
5	C5	96+2+2	27.12	45.1
6	C6	96+2+2	26.99	45.6
7	C7	92+4+4	27.12	45.7
8	C8	92+4+4	27.55	45.8
9	C9	92+4+4	28.88	45.9
10	C10	88+6+6	26.9	45.8
11	C11	88+6+6	27.5	46.8
12	C12	88+6+6	29.5	12
13	C13	84+8+8	28.5	13
14	C14	84+8+8	29.4	14
15	C15	84+8+8	28.5	15
16	C16	80+10+10	29.8	16
17	C17	80+10+10	28.7	17
18	C18	80+10+10	29.5	18

6. CONCLUSIONS :

1. Mixing or Blending of Flyash with metakaolin in place of cement have given better result as compared to conventional concrete especially with equal proportion mixing have been beneficial for improving strength at 28th day.
2. The highest strength achieved by mixing 10% of metakaolin and 10% Flyash was achieved. The highest 28-days strength improvement of concrete can be achieved with such type of partial replacements in the 15-20% range depending upon the cost requirement as mekaolin is costlier than cement.
3. Metakaolin helps in improving early strength of concrete as well as the ultimate strength also improves significantly by 10-15%.
4. We know flyash is a very cheaper material but to compensate the extra cost of metakaolin it has proven beneficial.

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