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Replacement of Fine Aggregate with Metakaolin

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Abstract—*Concrete a composite material made from cement, water, fine-aggregate and coarse aggregate. But present researchers are in interest of finding new cement materials by waste materials or waste products produced from industries which are harmful to environment. The present paper deals with the partial replacement of fine aggregate with metakaolin. The use of supplementary cementitious materials such as fly ash, silica fume, slag and metakaolin in concrete improves workability, reduces the heat of hydration, minimizes cement consumption and enhances strength and durability properties by reducing the porosity due to the pozzolonic reaction. Metakaolin is a highly pozzolanic and reactive material. In this paper emphasize has been given to metakaolin as partial replacement of fine aggregate at various percentages. The effect of metakaolin on the strength properties was analyzed by conducting compressive and flexural strength tests and durability properties were evaluated by water absorption and bulk density analysis. Making the various percentages of Metakaolin was made in partial replacement of fine aggregate and results were found that metakaolin usage in partial replacement to fine aggregate can be made.*

Keywords*: concrete, metakaolin, fine-aggregate, partial replacement.*

1. INTRODUCTION

Leaving waste materials in to environment directly results to damage of natural climatic conditions, hence use of waste materials is made at most importance in present study. Metakaolin is a pozzolanic material which is manufactured from selected kaolin, after refinement and calcinations under specific conditions. It is highly efficient pozzolana and react with rapidly with the excess calcium hydroxide resulting from OPC hydration, via a pozzolanic reaction to produce calcium silicate hydrates and calcium aluminosilicatehydrates .

It differs from other supplementary cementitious materials like fly ash, slag or silica fume, in that it is not a byproduct of an industrial process, it is manufactured for a specific purpose under controlled conditions. It is produced by heating kaolin, one of the most abundant natural clay minerals, to temperature of 650-900C. This heat treatment or calcinations, serves to breakdown the structure of kaolin. The particle size of metakaolin is smaller than cement particles, but not as fine as silica fume.

2. LITERATURE REVIEW

Aiswarya S, Prince Arulraj G, Dilip C

In 2013 examined a review on use of metakaolin in concrete. This paper reviews the use of metakaolin as supplementary cementations material in concrete. From the recent research works using Metakaolin, it is evident that it is a very effective pozzolanic material and it effectively enhances the strength parameters of concrete.

Sadr Momtazi, Ranjbar. M. M, Balalaei. F, Nemati. R

It examined the effect of Iran's metakaolin in enhancing the concrete compressive strength. This paper presents the performance of metakaolin (NCCM) on compressive strength and durability of concrete. Fired (Calcinated) NCCM has a very good pozzolanic, which could be partially replaced with Portland cement. It can decrease permeability, increase compressive strength and concrete durability. In this study, four different type of metakaolin which one of them was made in UK and the others were from different part of Iran were used. The results indicate that the replacing NCCM up to 20% has noticeable effect on compressive strength in comparing with mixture without metakaolin.

Patil1, P. D. Kumbhar

It examined that “ Strength and Durability Properties of HighPerformance Concrete incorporating High Reactivity Metakaolin” the present paper deals with the study of properties namely workability,compressive strength and durability of M60 grade HPC mixes incorporating different percentages of high reactivity metakaolin by weight of cement along with some suitable super plasticizer. The results of the study indicate that theworkability and strength properties of HPC mixes improved by incorporating HRM up to a desirable content of 7.5% by weight of cement. HPC mixes have also indicated better resistance to the attacks of chemicals such as chlorides and sulfates when the HPC mixes were exposed to theses chemical for 180 days period.

Dhinakaran (2012)

It studied the strength increases by MK concrete is effective only at the early age of concrete and in the long term the strength increase is only marginal. The increase in compressive strength for MK concrete was greater especially at higher water cement ratios (i.e., 0.4 and 0.5e. The minimum rate of reduction of chloride penetration depth for MK admixed concrete were arrived as 78%, 38%, 25% and 25% for w/cm ratios 0.32, 0.35, 0.40 and 0.50 respectively. The maximum rate of reduction was observed as 95% for 0.32 and 0.3 ratios.

Nova John (2013)

They 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.

3. MATERIAL PROPERTIES

3.1. Cement

Cement is a fine, gray powder that is used as a construction binding material (Fig.1). When mixed with water, cement reacts chemically and becomes hard and strong. Cement is categorized as either hydraulic or non-hydraulic, depending on how it mixes with water.

Fig. 1: Cement

Fig. 2: Fine Aggregates

3.2. Fine aggregate

Fine aggregate are generally consist of natural sand or crushed stone with most particles passing through a 9.5mm sieve (Fig.2). Locally available river sand which is free from organic impurities is used. The properties of fine aggregate are grading, durability, particle shape and surface structure, abrasion and skid resistance, unit weights and voids, absorption and surface moisture.

3.3. Coarse aggregate

The material which is retained on BIS test sieve 4.75mm is termed as a coarse aggregate (Fig.3). The nature of work decides the maximum size of the coarse aggregate. Locally available coarse aggregate having the maximum size of 20mm was used in our work. The aggregate were washed to remove dust and dirt and were dried to surface dry condition.

3.4 Water

Water is used for both mixing and curing should be free from injurious amount of deleterious materials. Potable water is generally considered satisfactory for mixing and curing concrete. In the present work potable tap water was used.

3.5 Metakaolin

Metakaolin manufactured from pure raw material to strict quality standards. Metakaolin is a highquality pozzolanic material (Fig.4). Metakaolin, which when blended with Portland cement improves the strength and durability of concrete and mortars.

Fig. 3: Course Aggregates

Fig. 4: Metakaolin

Metakaolin removes chemically reactive calcium hydroxide from the hardened cement paste. It reduces the porosity of hardened cement paste. Metakaolin densities and reduces the thickness of the interfacial zone, thus improving the adhesion between the hardened cement paste and particulars of sand or aggregate Table 1 &2. Shows physical and chemical properties of metakaolin.

Table 1: Physical properties of metakaolin

PARTICULARS	VALUES
Appearance	Off- White Powder
pH (10% solids)	4.0-5.0
Bulk density(kg/l)	0.4-0.5
Specific gravity	2.6
Loss of ignition(%)	1.5
Lime reactivity	1050mg ca(OH)2/g
Grift (+300#)	<1%
D50	1.5~2

Table 2: Chemical properties of metakaolin

CHEMICAL COMPOSITION	MASS (%)
SiO2	52.0-54.0
Al2O3	44.0-46.0
Fe2O3(Max)	0.60-1.2
TiO2(Max)	0.65
CaO(Max)	0.09
MgO(Max)	0.03
Na2O(Max)	0.10
K2O(Max)	0.03

4. TESTING METHOD:

4.1. Compressive strength test:

The size of the standard cube of size 150mm x 150mm x 150mm were used to determine the compressive strength of the concrete. Three specimens were tested for 28 days with varying proportions of metakaolin and finding the optimize value. These were compared with the conventional concrete mix. The constituent were weighed and the materials were mixed by hand mixing. The specimen were remolded after 24 hours, cured in water for 28 days, and then tested for its compressive strength. The compressive strength of the cube specimen is calculated using the following formula

Compressive strength, Fc = P/A N/mm2

Where, P = Load at failure in N

A = Area subjected to compression in mm2.

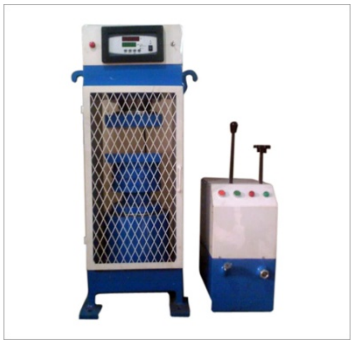

Fig. 5: Compressive Strength Test Apparatus

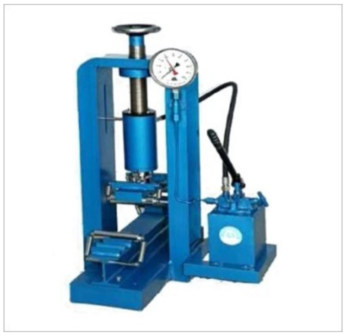

Fig. 6: Flexural Strength Test Apparatus

4.2. Flexural strength test:-

The flexural strength of the specimen is calculated using the following formula

Flexural strength, fb = 3PL/ 2bd2 N/mm^2

AUTHOR	% OF REPLACEMENT METAKAOLIN	7 Days		28 Days	
		Compressive strength	Flexure strength	Compressive strength	Flexure strength
MERIN (2015)	0%	27.42	4.63	41.6	6.28
	2.5%	28.80	4.93	42.53	6.49
	5%	29.13	5.02	43.25	6.50
	7.5%	31.33	5.32	44.45	6.64
	10%	32.34	5.34	47.58	6.93
	12.5%	29.80	5.21	43.60	6.70
Dr DEEPA (2016)	0%	45.1	-	61.9	6.3
	5%	50.9	-	64.6	6.6
	10%	51.9	-	70.4	7.0
	15%	54.8	-	72.7	7.2
	20%	51.4	-	69.6	6.8
RAHANE (2014)	0%	28.4	-	37.04	5.84
	4.79%	32.07	-	38.22	6.12
	8.22%	38.07	-	43.70	6.32
	10.45%	41.19	-	51.56	6.73
	15.24%	38.96	-	45.49	6.45

5. CONCLUSION

1. In this project to utilize the Metakaolin as a replacement of fine aggregate in construction industry. The percentage replacements of metakaolin is varied in percentages.
2. In both compressive & flexure test results it shows that when compare to conventional concrete the various percentage replacement concrete strength are increases.
3. The inclusion of metakaolin in fine aggregate has positive impact on the rheological properties in terms of workability& compactability.
4. The workability measured in terms of compaction factor test decreases with the increase of the replacement level of the fine aggregates with the MK.
5. The results encourage the use of Metakaolin, as a pozzolanic material for partial replacement in producing high performance concrete.

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