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Study Of Influence Of Micro Structural Parameters On Workability And Compressive Strength Of Metakaolin Blended High Performance Concrete

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Abstract

The present paper deals with the influence of percentage metakaolin (0, 10, 20 and 30 replacing cement by weight), water-binder ratio (0.325, 0.35, 0.375 and 0.40) and the aggregate-binder (2.0 and 2.5) ratio on the workability and compressive strength of HPC. The experimental work is carried out in the laboratory with locally available materials. A suitable super-plasticiser SP-337 is used to achieve the homogeneity of the sample. It is observed that the workability increases with increase of W/B ratio, decreases with increase of A/B ratio and is adversely affected by the content of admixture metakaolin. Compressive strength is found to decrease with increase of W/B ratio and is maximum at 10% metakaolin addition and decreases with increase of A/B ratio.

Keywords: High Performance Concrete (HPC), Metakaolin, Water-binder (W/B) ratio, Aggregate-binder (A/B) ratio, Workability (Compaction factor CF) and Compressive strength (C).

Introduction

Deterioration, long term poor performance, inadequate resistance to holistic environment, coupled with greater demands for more sophisticated architectural form guided the accelerated research into the micro-structure of cements and concretes and more elaborate codes and standards. Consequently, new materials and composites are developed and improved cements evolved.

ACI defined HPC as "*Concrete meeting special combinations of performance and uniformity requirements that cannot always be achieved routinely using conventional constituents and normal mixing, placing and curing practices*".

High performance concrete can be considered a logical development of cement concretes in which, the ingredients are proportioned and selected to contribute efficiently to the various properties of cement concrete in fresh and hardened states.

Mineral Admixture

Addition of mineral admixtures to concrete reduces heat of hydration due to reduced cement content and increases durability by contributing to the pore refinement Khatib et al. [1]. Metakaolin being a natural pozzolana is used in the current work due to its high pozzolanic activity and low cost. Walters et al. [2] found that metakaolin to binder ranging from 10 to 15 per cent yielded good strength and durability for high-strength concrete. IS: 456 - 2000 recommended metakaolin as mineral admixture. Hassan et al. [3] showed that mineral admixtures improved the properties of super-plasticized HPC, but at different rates depending on the type of binder. Ganesh Babu and Dinakar [4] reported that the overall strength efficiency of metakaolin concrete was dependent on age and percentage of metakaolin replacing cement by weight. Siddique and Klaus [5] used metakaolin as partial replacement of cement in concrete and reported the properties of fresh concrete as well as the mechanical and durable properties.

Materials and Parameters

a) Cement **b)** Coarse-aggregate (crushed granite) **c)** Fine-aggregate (river sand)

d) Water **e)** Metakaolin and **f)** Conplast SP-337 super-plasticizer at 1.0 per cent by weight of cement

Aggregate-binder ratio 2.0 and 2.5

%MK replacing cement by weight 0, 10, 20 and 30 and Water-binder ratio 0.325, 0.35,0.375 and 0.40

Testing

Compaction factor test (as per IS: 1199 - 1959) in fresh state of mixes and **Compression test** on cubes of 150 x 150 x 150 mm size cubes (as per IS: 516 - 1959) are conducted. Absolute volume method is used for proportioning the mix.

Table 1 Results of experiments on various MKHPC mixes

A/B	MK (%)	W/B	CF	C (MPa)
2	0	0.325	0.841	68.65
		0.350	0.853	65.82
		0.375	0.855	64.14
		0.40	0.858	62.21
	10	0.325	0.833	74.22
		0.350	0.835	69.74
		0.375	0.838	66.78
		0.40	0.845	65.21
	20	0.325	0.824	67.05
		0.350	0.826	60.73
		0.375	0.829	56.13
		0.40	0.831	52.53
	30	0.325	0.785	61.95
		0.350	0.789	54.47
		0.375	0.791	52.25
		0.40	0.795	50.29

A/B	MK (%)	W/B	CF	C (MPa)
2.5	0	0.325	0.823	64.52
		0.350	0.843	60.15
		0.375	0.851	56.85
		0.40	0.855	55.28
	10	0.325	0.812	70.15
		0.350	0.821	66.44
		0.375	0.832	62.75
		0.40	0.835	61.23
	20	0.325	0.784	65.34
		0.350	0.791	56.95
		0.375	0.808	52.35
		0.40	0.813	50.47
	30	0.325	0.775	58.23
		0.350	0.777	50.72
		0.375	0.781	49.25
		0.40	0.784	47.74

Results and Discussions

Effect of Water-Binder (W/B) ratio on Compaction Factor (CF)

Fig.1 shows that CF (workability) of MKHPC increases with increase of W/B ratio, which agrees with the results of earlier works, the reason for this being availability of more water in the mix at higher W/B ratios.

Effect of Percentage Weight of Metakaolin (%MK) on Compaction Factor (CF)

From Fig.2 it is found that CF (workability) of MKHPC decreases with increase of %MK and hence, the dosage of admixture must be clearly estimated before it is being used in concrete.

Effect of Aggregate-Binder (A/B) ratio on Compaction Factor (CF)

Fig. 3 shows that CF (workability) of MKHPC decreases with increase of A/B ratio. At higher A/B ratio, the concrete is leaner. In lean concrete, less quantity of paste is available to provide lubrication per unit surface area of aggregate. Hence, the mobility of aggregate is restrained. With lower A/B ratio, more paste is available to make the mix cohesive and fatty to give better workability. Higher paste acts as ball bearings between aggregate particles giving greater workability.

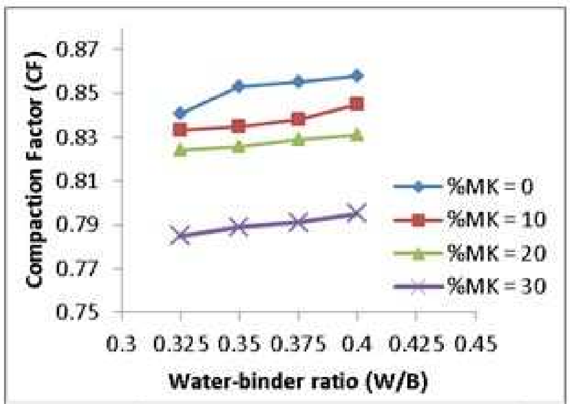

Fig.1 Effect of W/B ratio on CF at various Percentages of Metakaolin at A/B =2

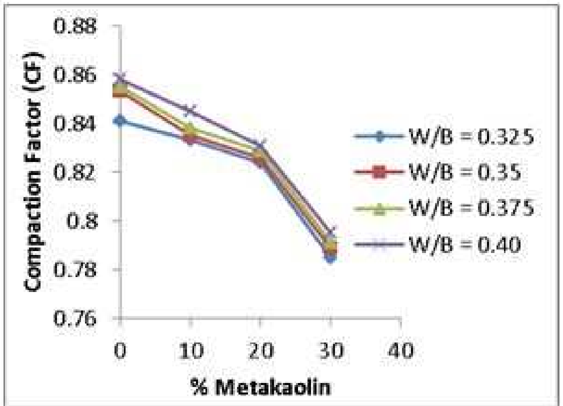

Fig.2 Effect of Percentage of Metakaolin on CF at various W/B ratios at A/B = 2

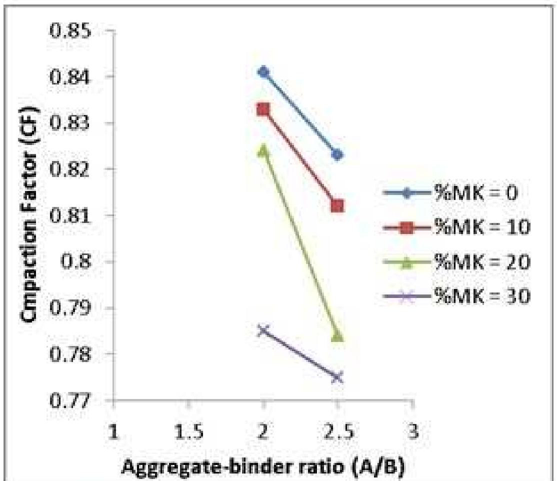

Fig.3 Effect of Aggregate -binder ratio on CF at various %MK at W/B = 0.325

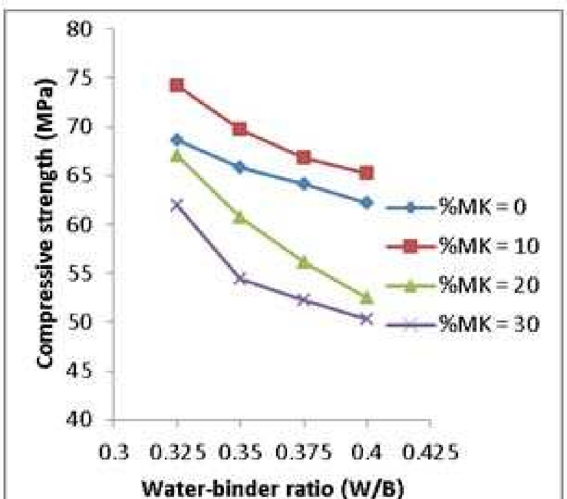

Fig.4 Effect of W/B ratio on Compressive strength at various %MK at A/B =2

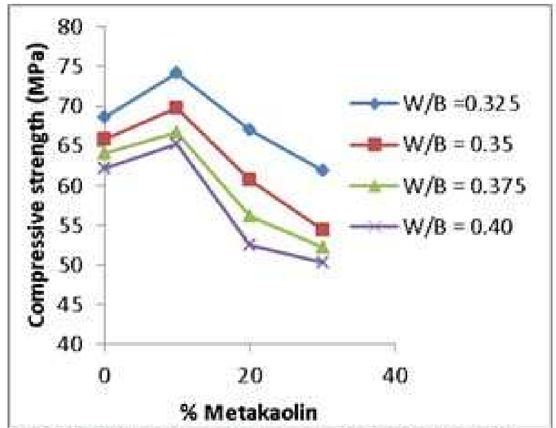

Fig.5 Effect of % MK on Compressive strength at various W/B ratios at A/B =2

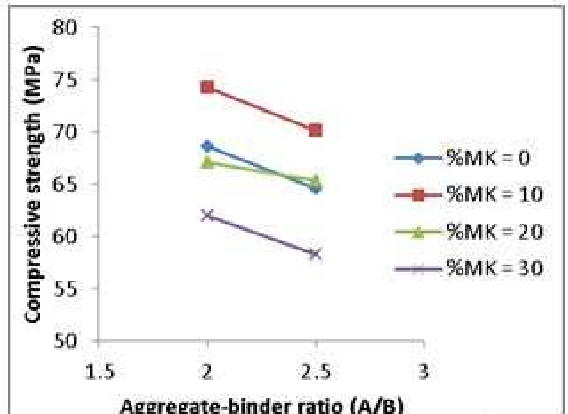

Fig.6 Effect of A/B ratio on Compressive strength at various % MK at W/B = 0.325

Effect of Water-Binder (W/B) ratio on Compressive strength (C)

From Fig.4 compressive strength of MKHPC is found to decrease with increase of W/B ratio for fixed %MK content and A/B ratio. This observation is akin to that of Abram's law for plain concrete, which states that the strength of concrete is only dependent upon water-cement ratio provided the mix is workable. It is clear that the compressive strength varies linearly with W/B ratio.

Effect of Percentage Weight of Metakaolin (%MK) on Compressive strength (C)

From Fig.5 it is found that addition of 10%MK replacing cement by weight is considered the optimal value to achieve the maximum compressive strength for MKHPC.

Effect of Aggregate-Binder (A/B) ratio on Compressive strength (C)

From Fig. 6 it is found that the compressive strength of MKHPC decreases with increase in A/B ratio and this decrease is mainly due to decrease in binder content for mixes with a higher A/B ratio. A lower A/B ratio indicates richer mix and hence, higher compressive strength.

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