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SELF-CURING ASSESSMENT OF META KAOLIN BASED HIGH STRENGTH CONCRETE USING SUPER ABSORBENT POLYMER

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ABSTRACT

This Paper describes the possibilities of Metakaolin as one of the mineral admixtures to produce high strength concrete. In this study literature regarding high strength concrete (HSC) and self- curing agents like super absorbent polymers (SAP) was studied. Poly vinyl alcohol and poly acrylic acids are the water soluble polymer has been tried as self -curing agent. The ordinary Portland cement was replaced in varying percentages by using Meta kaolin and found out optimum dose of it which produces high strength concrete. The mechanical property like compressive strength was evaluated. This study is an experimental investigation to determine the effect of polyvinyl alcohol and poly acrylic acid solely on compressive strength of kaolin based concrete at low water cement ratio 0.38. The concrete containing polyvinyl alcohol and poly acrylic acid separately with Meta kaolin enhances mechanical properties, not only due to pozzolanic reaction, but also due to its ability to retain water inside concrete.

Key words: High strength Concrete, Highly reactive Metakaolin, Polyvinyl alcohol, Poly acrylic acid, Self- curing, super absorbent polymers etc

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1. INTRODUCTION

Concrete produced by using mineral admixtures like micro silica, Metakaolin is a higher strength concrete of denser nature. It may lead to less water evaporation from the surface also it do not allows water to penetrate or very slow penetration and not in a sufficient amount. So the effect of curing can therefore be neglected. Many researchers showed failure of traditional

curing methods for HSC. Self-curing or internal curing is a technique that can be used to provide additional moisture in concrete for effective hydration of cement. Presently two methods are available for internal curing first method used saturated light weight aggregate (LWA) and the second is the use of super absorbent polymers (SAP)which reduce water evaporation and also helps in water retention. (Gemma Rodriguez de sensale et al.(2014)).The concept of self-curing agents is to reduce the water evaporation from concrete, and hence increase the water retention capacity of concrete compared to conventional concrete. It was found that water soluble polymers can be used as self-curing agents in concrete. (A.S.EI-Dieb(2007)).The effectiveness of using self-curing agents in mixes that include supplementary cementing materials (such as silica fume ,fly ash) has, however ,received little attention in the published literature.(Amr S. El-Dieb (2012)).The aim of this investigation was therefore to evaluate the use of water soluble polyvinyl alcohol as self-curing agent in OPC mixes incorporating Metakaolin.

2. MATERIALS AND METHODS

2.1. Metakaolin

Metakaolin is refined kaolin clay that is fired (Calcined) under carefully controlled conditions to create an amorphous alumino silicate that is reactive in concrete. Like other pozzolans (fly ash and silica fume are two common pozzolans), metakaolin reacts with the calcium hydroxide (lime) byproducts produced during cement hydration .Metakaolin's reaction rate is rapid, significantly increasing compressive strength, even at early ages, which can allow for earlier release of formwork. The presence of High reactive Metakaolin accelerates the consumption of Ca (OH) $_2$ results to the

Subsequent modification of the microstructure of concrete, and improves strength and durability properties of material. (Poon C.S. et al. (2001)).Fig.1 shows its physical form and Table1 describes its chemical properties.

Figure 1 Meta kaolin

Table 1 Chemical Properties

Sr. No	Constituents	In Percentages
1	SiO_2	52.8
2	Al_2O_3	36.3
3	Fe_2O_3	4.21
4	MgO	0.81
5	CaO	<0.10
6	K_2O	1.41

2.2. Polyvinyl Alcohol (PVA)

Polyvinyl alcohol is a white and granular, it is soluble in hot water but insoluble in cold water and common organic solvents. For many applications Polyvinyl Alcohol is prepared in water solutions. On evaporation of water, transparent films are formed which have high tensile strength and tear resistance. The binder characteristics of Polyvinyl Alcohol offer excellent adhesion to porous, water-absorbent surfaces. Polyvinyl alcohol is produced commercially from polyvinyl acetate, usually by a continuous process. It can be used as shrinkage reducing admixture in concrete.

2.3. Poly Acrylic Acid (PAA)

Dry poly acrylic acid is white soft powder, soluble in water. When it mixed with water many of the side chains of PAA will lose their protons and acquire a negative charge. This makes the ability to absorb and retain water and swell to many times their original volume.

2.4. Methodology

It has been reported that the replacement of Cement 5% to 15%HRM results in significant increase of compressive strength for producing high strength concrete, especially in early ages.(Kostuch J.A.et al.(1993)).The present experimental research program was carefully designed to determine the effect of the met kaolin on concrete properties. Hence while performing the investigations only cement is to be replaced by met kaolin in varying percentages (5%, 7.5%, and 10% by the weight of cement).The concrete mix design prepared by using IS 10262:2000.Optimum percentage of met kaolin was found out that gives desired strength. Water reducing admixture (Trade name: Sika) was used to provide workable mix. Control mix was prepared by using optimum dose of Metakaolin. There after control mix was unified with Poly vinyl alcohol and poly acrylic acid separately in varying percentages to evaluate its self -curing ability.

2.4.1. Mix design calculations as per (IS 10262:2009)

High strength concrete produced using highly reactive Meta kaolin as per the Indian standard method. The number of trial batches tried and proportion finalized is as shown in Table 2.The target mean strength decided was 68.25 N/mm^2

Table 2 Design mix proportion

	Water	**Cement**	**Fine aggregate**	**Coarse aggregate**
By weight (kg)	192.375	506.25	522.6	1242.85
By volume	0.38	1	1.03	2.45

Table 3 Mix Proportions

Meta kaolin %	**W/C Ratio**	**Water * (kg /m^3)**	**Chemical Admixture %**	**Cement (kg /m^3)**	**Metakaolin (kg /m^3)**	**Fine Aggregate (kg /m^3)**	**Coarse aggregate (kg /m^3)**
5	0.38	173.14	1	480.93	25.31	522.6	1242.85
7.5	0.38	173.14	1	468.28	37.96	522.6	1242.85
10	0.38	173.14	1	455.62	50.63	522.6	1242.85

*10% reduction in water content due to addition of Chemical admixture

2.4.2. Control mix

Control mix of different variation was prepared as per Mix proportions given in Table 3

Three cubes (150*150*150) mm size were casteof each proportion and water cured for 28 days. After 28 days compressive strength was found out by testing under compression testing machine.

2.4.3. Addition of PVA and PAA in different percentages in control mix

Once control mix finalized the PVA and PAA was added in control mix in varying percentages (0.02, 0.04, 0.06, 0.08 and 0.1percentages by the weight of cement). Mixing of all ingredients was done using a horizontal pan mixer for 2 minute. Six cubes of each proportion cast and kept them in room temperature for 28 days. Every day weight loss was observed.

3. RESULTS AND DISCUSSIONS

3.1. Compressive strength of Control Mix

It was observed that 10 % replacement level of cement by Meta kaolin was the optimum level in terms of compressive strength. Beyond 10 %replacement levels, the strength was decreased but remained higher than the control mixture. Compressive Strength of 106 MPa was achieved at 10 %replacement.(P Dinkar et al.(2013))

Strength tests revealed that concrete with 5%, 7.5% & 10% addition of Meta kaolin exhibits higher strength than the control mix at 28 days. The additions over 10% cause the concrete to have excess of high reactivity Meta kaolin to react with the hydrated calcium hydroxide and thus reduce the compressive strength of the concrete. The 7.5% addition of high reactivity meta kaolin in cement is the optimum percentage enhancing the compressive strength at 28 days by 7.73% when compared with the control mix specimen (B.B.Patil et.al.(2012)).

In this study compressive strength test conducted on cubes (water cured)and the results obtained were presented in Table4.Result illustrates that optimum replacement 7.5% by the weight of cement, produces strength nearly equal to target mean strength hence considered to be economical mix. The results obtained are also shown graphically in Fig.2

Table 4 Compressive Strength of concrete Mix for different variation of Metakaolin

Meta kaolin(%)	Specimens (CUBES)	Compressive strength after 28 days N/ mm^2	Average compressive strength N/mm^2
0	C1	61.50	61.51
	C2	62.44	
	C3	60.60	
5	C1	72.40	73.35
	C2	73.10	
	C3	74.55	
7.5	C1	66.34	66.65
	C2	67.10	
	C3	66.50	
10	C1	62.25	60.97
	C2	59.87	
	C3	60.81	

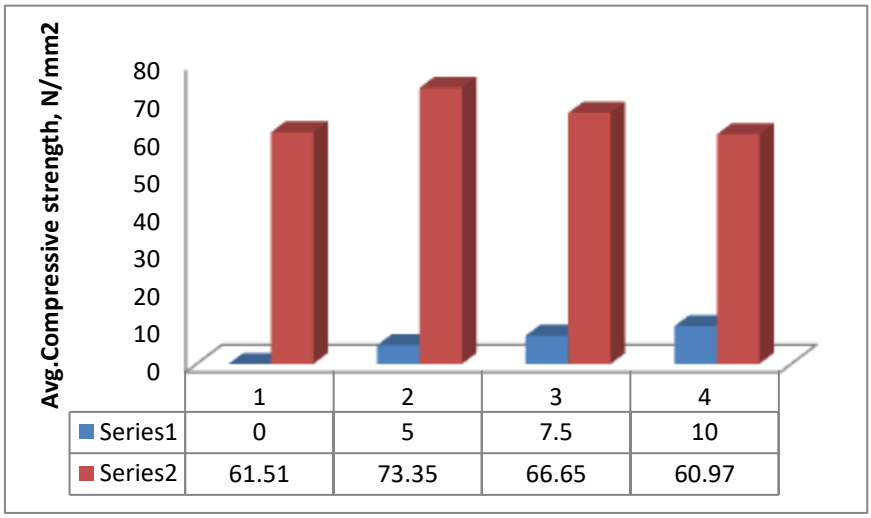

Figure 2 Compressive strength of control mix

3.2. Compressive strength of Meta kaolin based HSC unified by PVA and PAA

From the results in Table 4the optimum percentage of replacement of cement by Metakaolin is found to be 7.5%.Now for this control mix PVA and PAA added separately in varying percentages (0.02, 0.04, 0.06, 0.08 and 0.1percentages by the weight of cement). Casted Specimens air Cured at room temperature and every day weight loss was observed. From the weight loss observation, water lost only 1% it's negligible at the end of 28 days. Thereafter specimens were tested in compression. Concrete unified with poly vinyl alcohol of dose 0.04%is found optimum produces strength 65.40 N/mm^2 and Concrete unified with poly acrylic acid of dose 0.02% is found optimum produces strength 64.20 N/mm^2.Both strength obtained are nearly equals to strength of Control mix. Results obtained are as shown in Table 5 and represented graphically in Fig.3.

Table 5 Compressive Strength of HSC unified by PVAand PAAsolely

PVA/PAA in Percentages	0.02	0.04	0.06	0.08	0.1
Avg. compressive strength of PVA mixed cubes after 28 days, N/mm^2	61.81	65.40	60.5	55.9	52.86
Avg. compressive strength of PAA mixed cubes after 28 days, N/mm^2	64.20	63.5	58.5	54.2	50.6

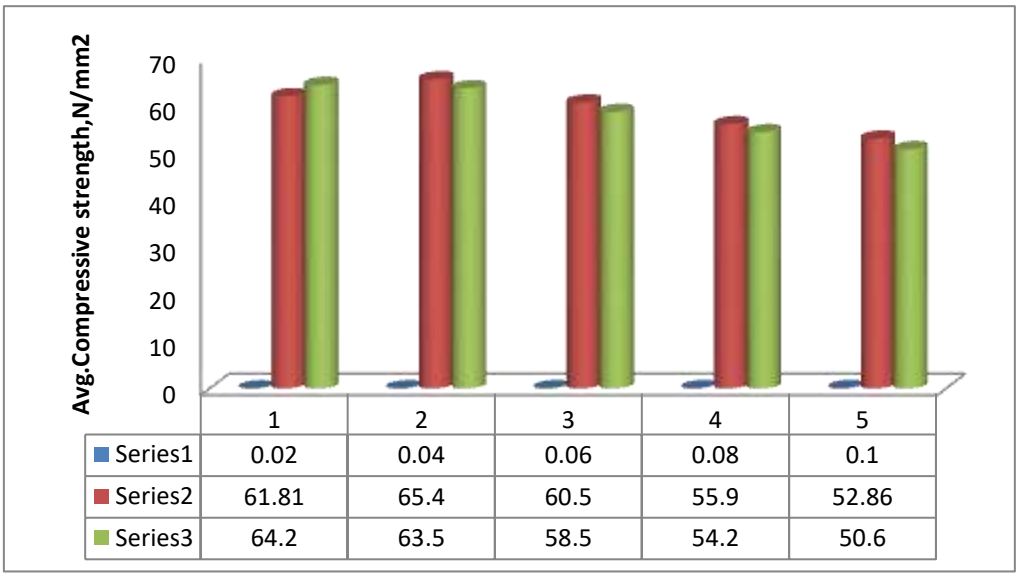

Figure 3 Compressive Strength of HSC unified by PVA and PAA

4. CONCLUSIONS

Concrete with low water cement ratios containing natural pozzolana such as used in this research; require an efficient curing application because of high water demand. Thus self - curing is promising alternative to fulfill water demand. From this study it can be concluded that replacing cement content with Meta kaolin by 7.5% and unified with Poly vinyl alcohol, poly acrylic acid solely would significantly shows water retention ability and improve compressive strength of high strength concrete produced. The polymers attempted are commercial still more comprehensive study needed to examine suitability in construction work. The various possible modifications can be made to produce new polymers which will best suited for only construction works. Clearly, more work is required to establish the durability of concretes with super absorbent polymers, the stability of SAP over time and in various exposure environments.

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