Influence of a new Viscosity Modifying Admixture (VMA) on the rheological properties of cement paste

Shaofeng Wang[1,a] , Hui Zhou[1], Yao Bi[1] , Xing Li[1], Jinwen Wang[1], Long Xiong[1] , Juxiang Xing[1]

[1] China Construction Ready Mixed Concrete Co. Ltd, Wuhan 430205, China,

[a] jaylia08@hotmail.com

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Abstract. This paper presented a new kind of Viscosity Modifying Admixture (VMA). Adsorption and rheological properties was studied on this new kind of VMA and Cellulose hydroxypropyl methyl ether Hyprolose. The results show that adsorption capacity of this new viscosity modifying admixture is greater than cellulose ether, and it could significantly increase the yield stress and the plastic viscosity of cement slurry. While Cellulose hydroxypropyl methyl ether Hyprolose can only improve yield stress of cement, it has little influence on the plastic viscosity.

1. Introduction

Large amount of consumption on high quality natural resources cause raw material degradation, this is the most important issues that ready-mixed concrete industry is facing. It leads to segregation, bleeding and bad workability of fresh concrete [1 ~ 2]. Meantime the sensitivity polycarboxylic superplasticizers on concrete aggravate the problem [3]. Amount of research results show that [4 ~ 6] layered segregation of concrete is mainly controlled by the yield stress, while the plastic viscosity affects bleeding of the concrete. Viscosity Modifying Admixture (VMA) to improve the workability of concrete by raising the yield stress and plastic viscosity of concrete.

The carboxyl in the molecular structure of this viscosity Modifying Admixture (VMA) adsorb on cement surface and molecules twines around cement particle, form a three-dimensional network structure to improve the yield stress of concrete. this viscosity Modifying Admixture (VMA) twines and swells, increases the viscosity of the slurry solution, further improve the plastic viscosity of concrete. Therefore this article discusses adsorptive property and thickening property on cement particles, studies the effect on cement rheological property.

2. Materials and methods

2.1 Raw materials

Acrylic acid (AA), ammonium persulphate (APS), thioglycollic acid (TGA),

Na_2SO_4,Acrylamide(AM) and sodium hydroxide (NaOH) are purchased from Sinopharm Chemical Reagent Co., Ltd. Polycarboxylate-type (PCE) superplasticizer is obtained from China Construction Ready Mixed Concrete Co. Ltd.Hydroxy Propyl Methyl Cellulose，Gomez chemical(China)Co.LTD

2.2 Synthesis of the samples

Using AA, AM as monomers, free radical polymerization proceeded in aqueous solution. The initiator used here was ammonium persulfate. After samples cooled to room temperature, NaOH solution was used to regulated the pH to 7 ~ 9.

2.3 Characterization and evaluation of samples

The apparent viscosity of 1% VMA solution are determined by NDJ-5S rotational viscometer with rotor 4, test temperature is 22~25℃, Shear velocity is 12 R/min.

Adsorption capacity of VMA and PCE is calculated through the solution viscosity regulator/PCE concentration difference. The liquid phase is obtained by centrifuge separation, and then uses the total organic carbon analyzer determine the concentration of the residual VMA in liquid phase.Adsorption time for 5 minutes, then add a large number of acetone to terminate the cement hydration.

The water-cement ratio is 0.32, stirring for 4 mins. Using the rheometer(200 pa shear stress) to determine water slurry apparent viscosity, test temperature is 20℃.

3. Results and discussion

3.1 The influence on the solution viscosity of viscosity regulator

Viscosity Modifying Admixture (VMA) agent on the viscosity of concrete mainly comes from the solution volume swell increasing fluid mechanics . Because the cement paste contains a large amount of inorganic salt, while they usually has strong hydration. They compete with cellulose ethers of tackifier hydration compete. If the hydration of ion hydration is stronger than the cellulose ether, make cellulose ether salting out from solution, it is also a most reason that Cellulose ether and poly carboxylic superplasticizers have poor intermiscibility.

Fig.1shows when the concentration of inorganic salt increases, the viscosity of cellulose plunge, especially the viscosity of Na_2SO_4 come to 1.2%. It is as cellulose ether badly salting out from solution. Viscosity Modifying Admixture (VMA) synthesized in this study is obviously different with the former three trend, its viscosity appeared a certain amount of rise.

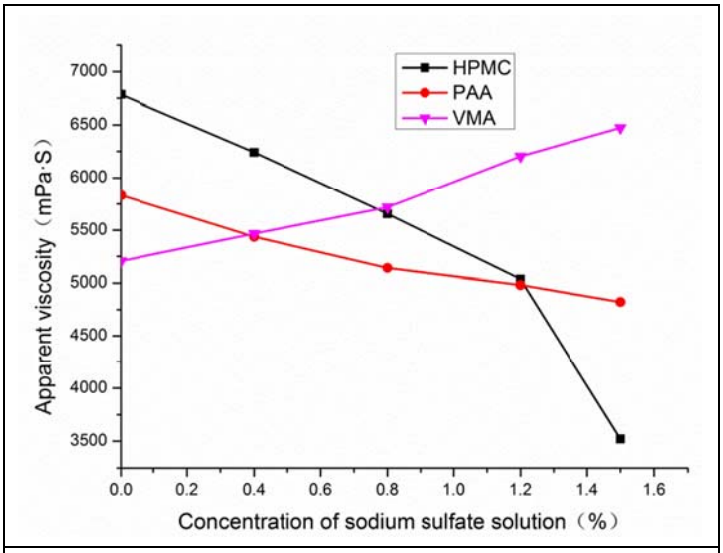

Fig1. The influence of inorganic salt on the solution viscosity

3.2 Effect on cement adorption with VMA

VMA adsorbs on cement particles is foundation of its increasing yield stress, We study on adsorption behavior of Viscosity Modifying Admixture (VMA) on blank cement particle and adsorption behavior of cement particle after mixed with poly carboxylic superplasticizers. The result is shown in Fig2.

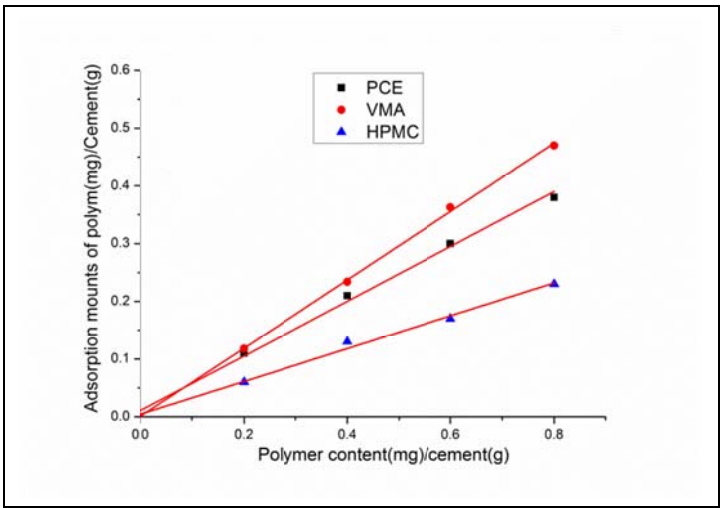

Fig.2 The adsorption curve of VMA

Fig2 shows the adsorption curve among superplasticizers, cellulose ether and VMA. When adsorption of superplasticizers less than 1.2 mg per gram of cement, they shows linear relationship. While the range of adsorption is 0-0.8mg, adsorption of VMA is 11% higher than superplasticizers, adsorption of cellulose ether is lower than superplasticizers.

3.3 Effort on rheological properties of cement paste with VMA

Cement paste slurry rheological parameters yield stress and plastic viscosity are

the main factors than influence the workability of concrete, hence this article studies the rheological properties of cement paste first. Fig3 shows the rheological curve between having VMA and not having VMA. Fig4 shows that the rheological curve of cement paste confirms to Bingham formula.

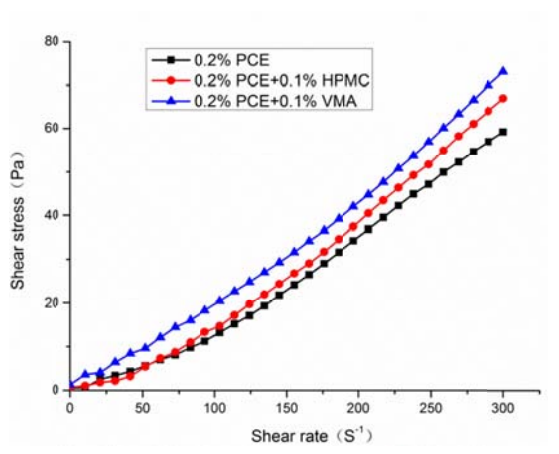

Fig.3 Rheological behavior of cement paste

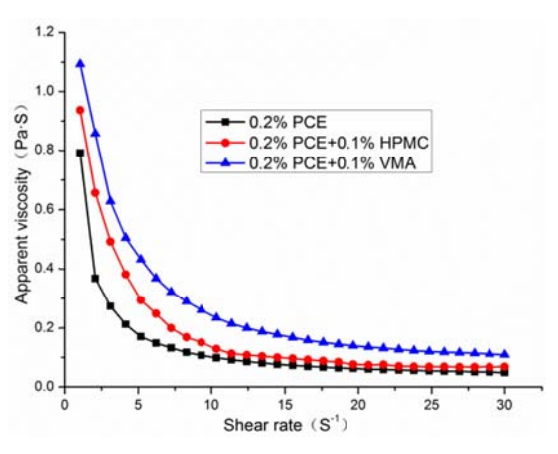

Fig.4 Apparent viscosity of cement paste with VMA

Fig5 and Fig6 show yield stress and plastic viscosity of cement paste with different modifying agent. The results show that yield stress is significantly improved when VMA dosage is 0.07% of the cement quality, while yield stress is a little reducing when the dosage of cellulose ether is 0.07%, meantime the yield stress is higher than blank, but still lower than cellulose ether. Fig6 shows VMA is better than cellulose ether in plastic viscosity respect.

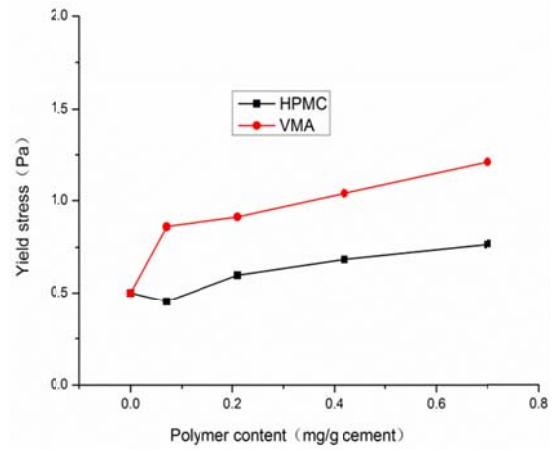

Fig5 Yield stress of cement paste with VMA

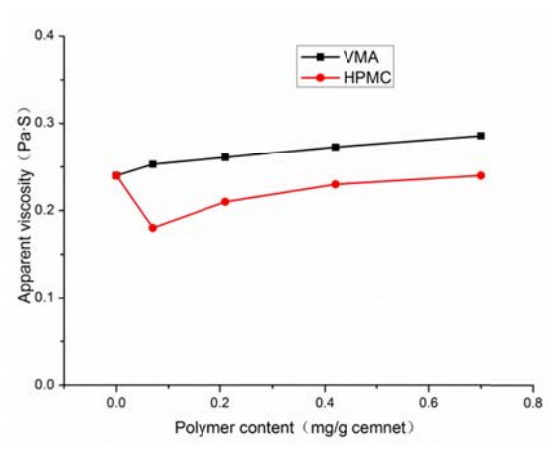

Fig6 Plastic viscosity of cement paste with VMA

4 Conclusion

We synthesize a new VMA with crylic acid and acrylimide that can improve

workability of concrete observably. Absorption of cement paste experiment shows that absorption ability is better than cellulose ether. We also discuss the influence on cement paste with this new VMA. The results show ordinary cellulose ether can only improve the yield stress, rarely impact on plastic viscosity. While this new VMA not only improves the yield stress of cement paste ,but also improves the plastic viscosity significantly, further improves the workability of concrete.

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