HIGH MOLECULAR WEIGHT CELLULOSE ETHER INFLUENCE ON THE ADHESIVE PROPERTIES OF FRESH MORTARS

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Received: 03 January 2014; Accepted for publication: 15 Jully 2014

ABSTRACT

This paper presents an experimental study on the effect of high molecular weight cellulose ethers on the adhesive properties of fresh mortars. The tack test was used. The results indicate an important role of the molecular weight of cellulose ether on controlling the adhesion force, the cohesion force of fresh mortars. However, a maximum value of the adherence force is observed, which indicates that for render mortar, it is better not to take this value of polymer concentration. Meanwhile, for tile adhesive mortar, other properties must be considered before determining the mortar formulation, including the flow-ability, the adhesive strength at hardened state, etc.

Keywords: adhesive properties; mortar; high molecular weight, tack test, cellulose.

1. INTRODUCTION

The term “cellulose ether” refers to a wide range of commercial products and differs in terms of substituent, substitution level, molecular weight (viscosity), and particle size. The most widespread cellulose ethers used in dry mortars as admixtures are the methyl cellulose (MC), methyl-hydroxyethyl cellulose (MHEC) and methyl-hydroxypropyl cellulose (MHPC) [1].

According to their properties, cellulose ethers are used in various industrial fields. They significantly modify the properties of materials even if they are introduced in small amounts (0.02 - 0.7 % [1]). They are used to control the viscosity of a medium, as thickeners or gelling agents. In mortar, cellulose can be added before or during the mixing as thickening and water retaining agents.

Hydroxyethyl methyl cellulose (HEMC) is a common admixture in mortars for various applications including cement spray plasters, tile adhesives, etc. The influence of HEMCs has been published by many researchers in the case of various application fields, such as biological macromolecules [2, 3], carbohydrate polymers [4, 5], etc. However, there are few published concerning the influence of HEMCs on the fresh state properties of cementitious materials including cement grouts [6, 7], cement-based mortars [10].

Patural et al. [8] had investigated the influence of cellulose ether on the properties of mortars in fresh state, in which the molecular weight is low (90 - 410 kDa). The effect of high molecular weight cellulose ether hasn't been studied. Thus, it is interesting to deal with high molecular weight cellulose ether in order to complement the effect of molecular weight of cellulose ether on the properties of fresh mortars, including the adhesive properties.

The adhesive properties of fresh mortars have been examined by several authors for investigating the influence of fibres [10], organic admixture [9] and recently for cellulose ether [11, 12]. It has been shown that tack measurements allow dissociating several aspects of practical interest, related to the adhesive properties [9], including the interface adherence, cohesion and adhesion strength.

2. MATERIALS AND EXPERIMENTAL METHODS

2.1. Mix-design

The binder comprises a Portland cement (CEM I 52.5 N CE CP2 NF from Teil-France) and a hydraulic lime (NHL 3.5Z). In order to minimize phase separation, the standard sand CEN EN 196-1 ISO 679 has been used. In this study, the effect of three types of high molecular weight cellulose ethers has been investigated. Their typical physical characteristics are introduced in Table 1.

Table 1. Typical physical characteristics of three types of HEMCs.

Properties	Type A	Type B	Type C
Form	Powder	Powder	Powder
Solubility	Water soluble	Water soluble	Water soluble
Viscosity (1), mPA.s	20,000	30,000	70,000
pH (2 % solution)	Neutral	Neutral	Neutral
Molecular weight	600,000	680,000	1,000,000

Note: (1) solution in water, Haake Rotovisko RV 100, shear rate 2.55 s^{-1}, 20 °C.

A certain dosage rate of an air-entraining admixture is used to guarantee moderate rheological properties within the resolution range of the rheometer.

The weight proportion of each constituent of the mortar is represented in Table 2.

Table 2. Mortar formulation.

Constituent	Cement	Lime	Sand	Air entraining	HEMC	Water
% wt of dry mixture	15	5	80	0.01	0.19-0.31	19

2.2. Test methods

The tack tests have been performed on a rheometer equipped with a two-parallel-plates geometry between which the fresh mortars are inserted, and then squeezed out at a given velocity to reach an initial gap thickness before separating them at different applied velocities.

The mortar sample, with the diameter of 40 mm, is compressed to the gap thickness of 3 mm. The material is left to rest for 3 minutes after casting in order to avoid possible memory effects. The plates are then separated under a constant velocity, which is chosen in range of 10 -500 µm/s. By recording the evolution of the nomal force with the instantaneous distance between both plates, three relevant properties can be directly identified, including the adhesion, the cohesion and the adherence force. For more details, we refer to Kaci *et al.* [10].

3. EXPERIMENTAL RESULTS

3.1. Evolutions of the adhesion force

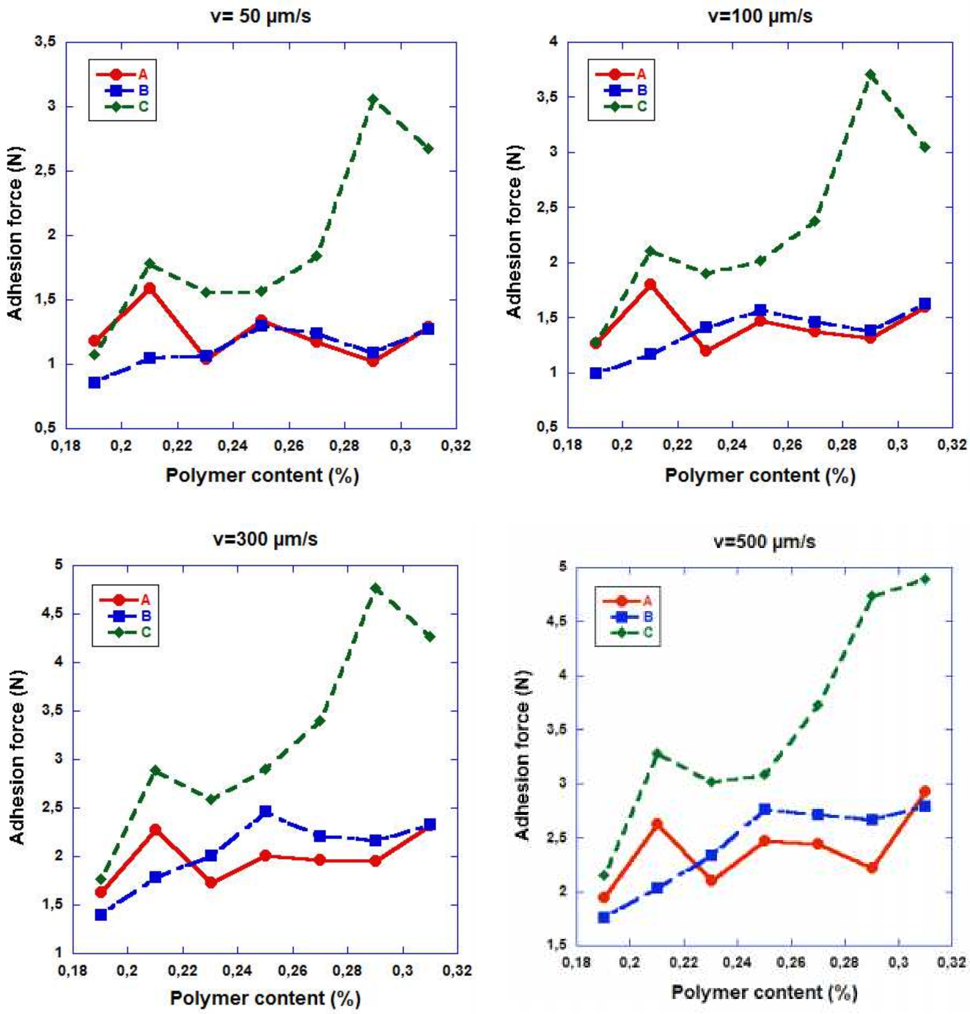

Figure 1. Evolutions of adhesion force with polymer contents, under different tack speeds.

The adhesion force increases with the enhancement of polymer concentration. However, one can notice the difference of the force evolution between the 3 polymers. The adhesive force of the mortar paste is always significantly higher in case of C, which has the highest molecular weight. It means that the molecular weight of polymers plays an important role in controlling the adhesive properties of mortars. Meanwhile the evolutions are almost similar in case of A and B, which have close molecular weights, especially at low pulling speed.

The net difference regarding the adhesive forces indicates that the high molecular weight cellulose ether is applicable to adhesive mortars, while low molecular weight cellulose ether are suitable to render mortars.

3.2. Evolutions of the cohesion force

The cohesion force is taken as the adhesion force at lowest pulling speed [10]. The evolution of the cohesion force, represented in Figure 2, is similar to the adhesion forces' evolutions. It is almost similar in cases of A and B, which have close molecular weight (600 - 680 kDa). Meanwhile, a significant increase of the cohesion force is observed in case of highest molecular weight polymer (1000 kDa), which strengthening the previous observation that high molecular weight cellulose ethers are applicable to adhesive mortars.

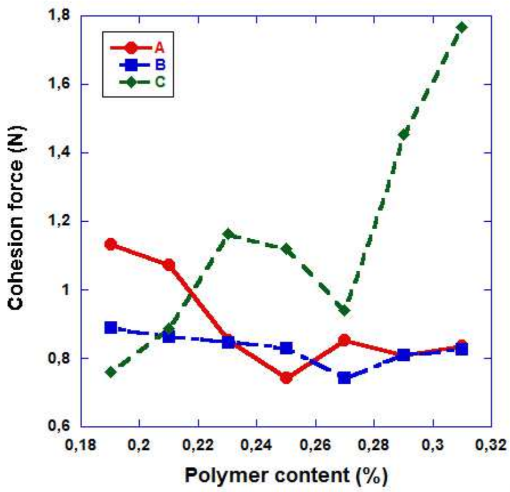

Figure 2. Evolutions of the cohesion force with polymer contents.

3.3. Evolutions of the interface adherence

The adherence is equal to the quantity of mortars remain stuck on the upper plate after finishing the experiment [10]. The evolutions of the adherence are plotted in Figure 3. The adherence force is always the highest at the content of 0.25 % for all the investigated samples. For other concentrations, the adherence force is quite low and almost unchanged. The average value is around 0.015 N. It is important to be noted that the same experiments have been performed at least 3 times with freshly prepared samples. Therefore, the local maximum in the adherence force is physical.

The results indicate that for high-molecular-weight-modified render mortars, it is better not to take the polymer concentration at 0.25 %, because of the high quantity of mortars that remain stuck on the working tool. However, for tile adhesive mortar, which does not deal with the adherence, this value does not a big problem. The most important factor in case of tile adhesive mortar is the adhesion force, which is found increase with the increase of polymer content in previous section.

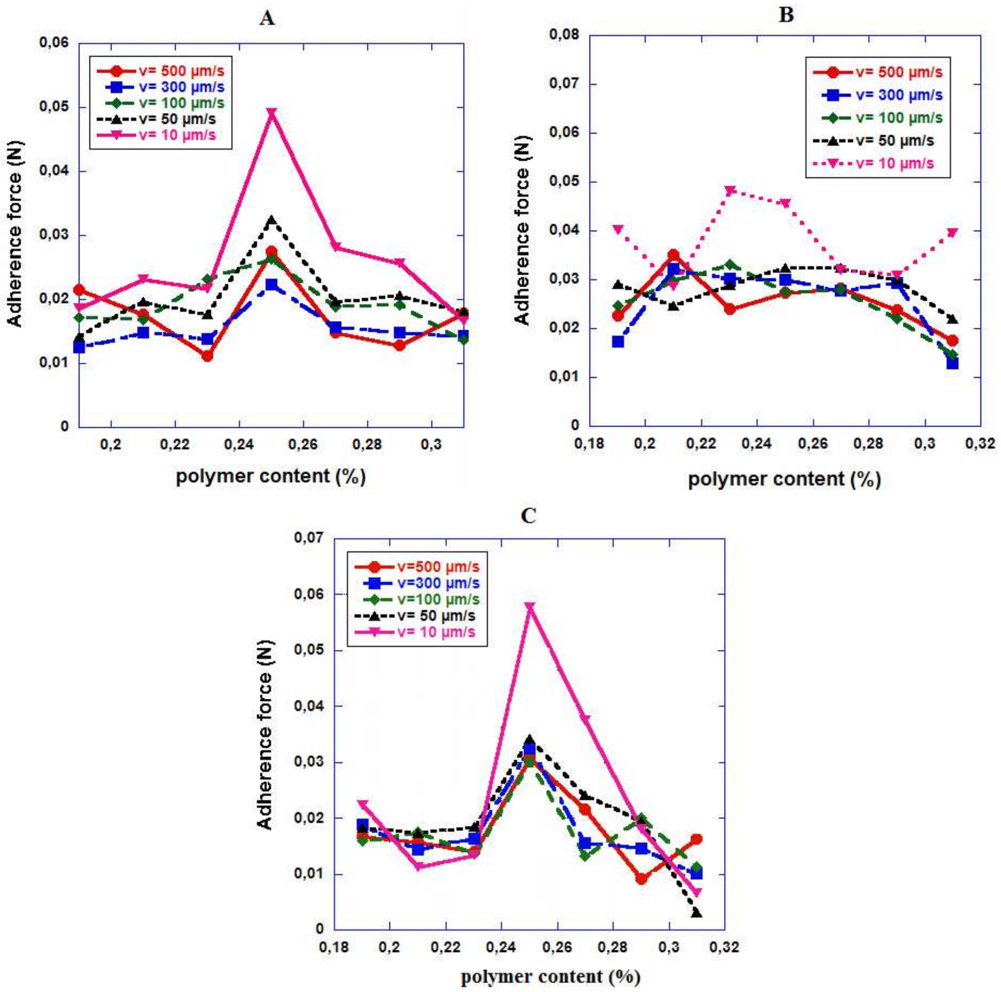

Figure 3. Evolution of the adherence force as a function of polymer content.

4. CONCLUSIONS

Adhesive properties of mortars in the fresh state have been investigated with varying contents of three types of hydroxyethyl methyl celluloses denominated A, B and C. The sensitivity of the adhesive properties of mortars relative to the variation of polymer concentration increases successively with the increasing of the molecular weight. The adhesion is almost unchanged with polymer concentration in case of A and B, which have low molecular weight, but significantly increases in case of C, the highest molecular weight one. The strongly effect of C, which has the highest molecular weight, has proved an important role of the cellulose ether's molecular weight in controlling the adhesive properties of mortars in fresh state.

The observed evolution of the cohesion forces with the variation of polymer contents are fairly similar to that of the adhesion force, while the evolution of the adherence force are more complex. A maximum value of the adherence indicates that for render mortar, it is better not to take this value of polymer concentration.

For tile adhesive mortars, the molecular weight is an important factor for modifying the adhesive properties. However, for each application, other properties must be considered, including the flow-ability, the adhesive strength at hardened state, etc.

Acknowledgments. We are grateful to the company ParexLanko-France for sponsoring this investigation.

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TÓM TẮT

ẢNH HƯỞNG CỦA PHỤ GIA XENLULO CAO PHÂN TỬ TỚI TÍNH DÍNH CỦA VỮA TƯƠI

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Bài báo trình bày nghiên cứu thực nghiệm về ảnh hưởng của phụ gia xenlulo cao phân tử tới tính dính của vữa tươi. Tính dính được xác định bởi thí nghiệm dính bám. Kết quả chỉ ra vai trò quan trọng của khối lượng phân tử tới lực dính và lực cố kết của vữa tươi. Sự phụ thuộc của các đại lượng lực dính và lực cố kết của vữa tươi khi sử dụng phụ gia có khối lượng phân tử lớn rõ rệt hơn hẳn so với 2 trường hợp sử dụng phụ gia có khối lượng phân tử thấp hơn. Do đó khi sử dụng phụ gia gốc xenlulo, khối lượng phân tử là yếu tố rất quan trọng để điều chỉnh tính dính bám của vữa tươi. Tuy nhiên, khi xem xét sức bám của vữa, kết quả cho thấy luôn tồn tại một giá trị cực đại của sức bám. Điều đó cho thấy không nên dùng phụ gia xenlulo cao phân tử ở hàm lượng 0,25 % với vữa trát. Tuy nhiên với vữa trát gạch, việc này không quá cần thiết. Đối với từng ứng dụng cụ thể, cần thiết phải xem xét thêm các tính chất của vữa, như tính chảy, cường độ dính kết ở trạng thái cứng, …

Từ khóa: lực dính; vữa xi-măng, xenlulo, khối lượng phân tử, vữa tươi, thí nghiệm dính bám.