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USE OF PHOSPHO MAGNESIUM COMPOUNDS AS CONCRETE REPAIR.

C. BAUX, C. LANOS, Y. MELINGE, L. MOLEZ, R. JAUBERTHIE

Laboratoire de Génie Civil et Génie Mécanique (LGCGM)

Institut National des Sciences Appliquées (INSA) – Université Européenne de Bretagne (UEB)

20, avenue des Buttes de Coësmes

CS 14315-35 043 Rennes Cedex, France

e-mail: raoul.jauberthie@insa-rennes.fr

KEYWORDS

Concrete repair, phospho magnesium binder, SEM, X-ray diffraction

ABSTRACT

Phospho magnesium compounds are tested to repair different typologies of concrete elements prepared with different surface roughness. Mechanical tests (flexion tests) show that rupture is logically conditioned by the type of preparation. SEM observations are realised along the rupture plan. The phosphate binder crystallized phases at the interface are very dense. When repaired surface is rough, the adhesion between the two phases (phosphate binder and Portland cement paste) is quite correct.

INTRODUCTION

Mortars and concrete, when altered, need to be repaired or strengthened. Various products and implementation techniques are used. The Concrete solutions congress held in Saint Malo during summer 2003¹, allowed one to point out the different ways to face this problem. The diagnostic methods for building sites or for laboratory studies have been presented elsewhere^{2,3,4}. Reinforced concrete has been more carefully studied in a paper presented to CEFA (Civil Engineering French Association)⁵.

The aim of the presented study is the development of a fast setting reparation mortar which would find its place in premises or workmanship for which the shortest time of closing is needed. The reparation material must be very adhesive towards the initial concrete and intrinsic properties (such as mechanical strength) as high as possible. Phosphate based binders seems to fit these requirements.

SELECTED MATERIALS

The cement is a CEM II 32.5 Portland cement (supplied by Lafarge, Saint Pierre la Cour, France). The sand is selected according to the European standard E 197-1. The mortar is prepared with a water-to-cement (W/C) ratio of 0.5. This mortar is kept under controlled atmosphere (20°C, 95% relative humidity RH) for one month. Then, the samples are sawed with a diamond saw or “manually” broken in several directions.

The reparation mortar is obtained by reacting a phosphoric acid salt and brucite in presence of water. An inert filler (mean particle size below 500µm) is added to the mixture. This particle size is chosen to fill the cracks and the pores of the materials to be repaired. A set regulating adjuvant is used to delay the set from 1 up to 10 minutes.

These two mortars are kept in controlled atmosphere (20°C, 95% RH) for 24 hours before removal from mould. Then, the samples are kept in the same conditions for one month. Two series of reference samples are mechanically tested after one more month. The 3-points-flexion strengths and the compression strengths are reported in table 1.

Table 1: Breaking strengths of reference mortars.

Strength (MPa)	CEM II	Phosphate based binder
Flexion	7.38	8.94
Compression	59.84	13.54

EXPERIMENTAL STUDY

Sample preparation

The samples prepared with Portland cement are sawed with a diamond saw. Three series of samples are thus obtained: 4x4x8 cm³ parallelepipeds, 2x4x16 cm³ parallelepipeds and trapezes (45° sawing). The sawed samples are placed in 4x4x16 cm³ moulds and the reparation mortar is poured in the empty volumes of the mould. The proportion of set regulating adjuvant is chosen to insure a setting time of 5 minutes. The interface contact between the different mortars is presented in figure 1a.

Another series is prepared but this time, the samples are broken manually with the help a hammer and a burin. The obtained surfaces are “splintered” and rough (see figure 1b). In this case, 4x4x8 cm³ and 45° trapezes have only been obtained.

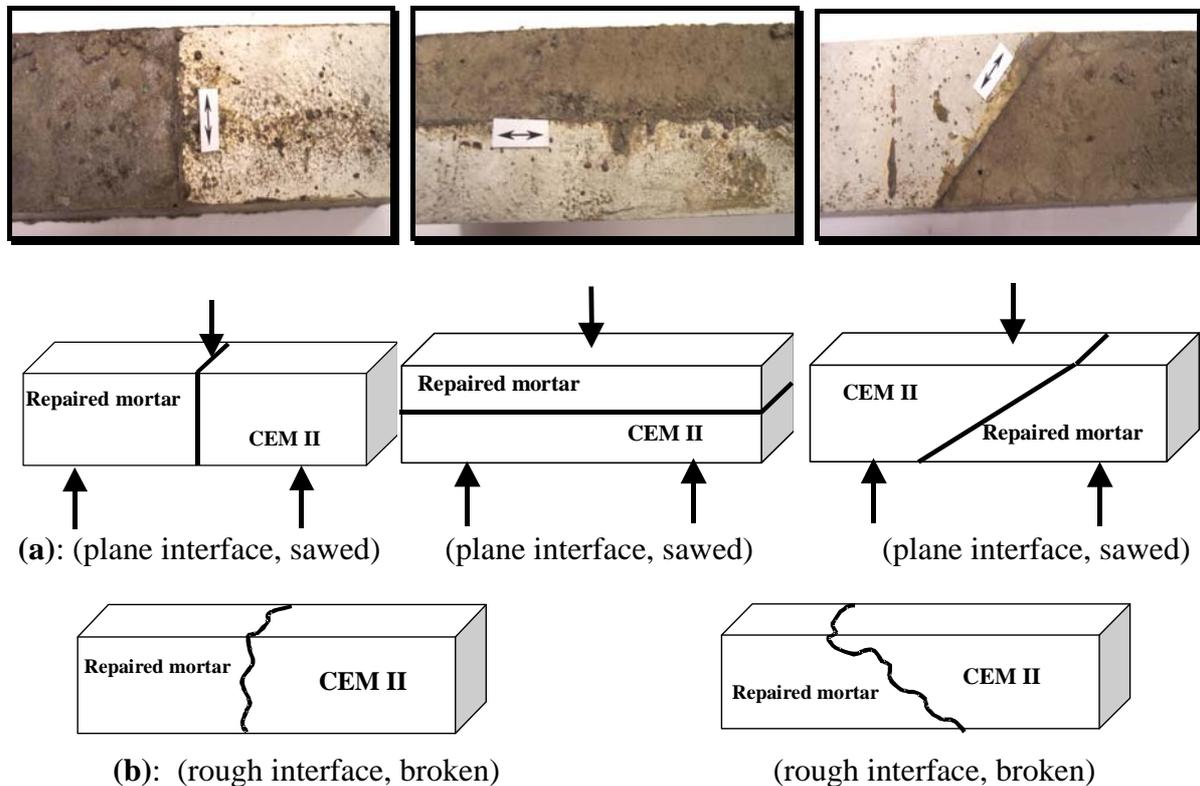


Figure 1: Examples of reparation orientations

Mechanical tests

After a maturation period each sample is tested in 3-points-flexion test. The different configuration and associated results are presented in figure 2. As expected, the flexion strength is weaker when the maximum constrain plan is the reparation plan. When the reparation plan is 45° oriented, flexion strengths are higher and the highest value is obtained when the reparation plan is perpendicular to the applied force. Anyway, the rupture propagate more easily along with the reparation plan with a slight variation as can be seen on figure 3a. Finally, when the applied force is perpendicular to the reparation

plan, the highest obtained resistances are when the tensed face is made of Portland cement mortar (see Figure 3b). In this case, the rupture starts in the Portland cement mortar (and require thus a higher applied force) and propagate through the phosphate binder. If the sample are put upside-down *i.e.* phosphate binder face downwards (see figure 2), the cracking of the tensed face starts earlier.

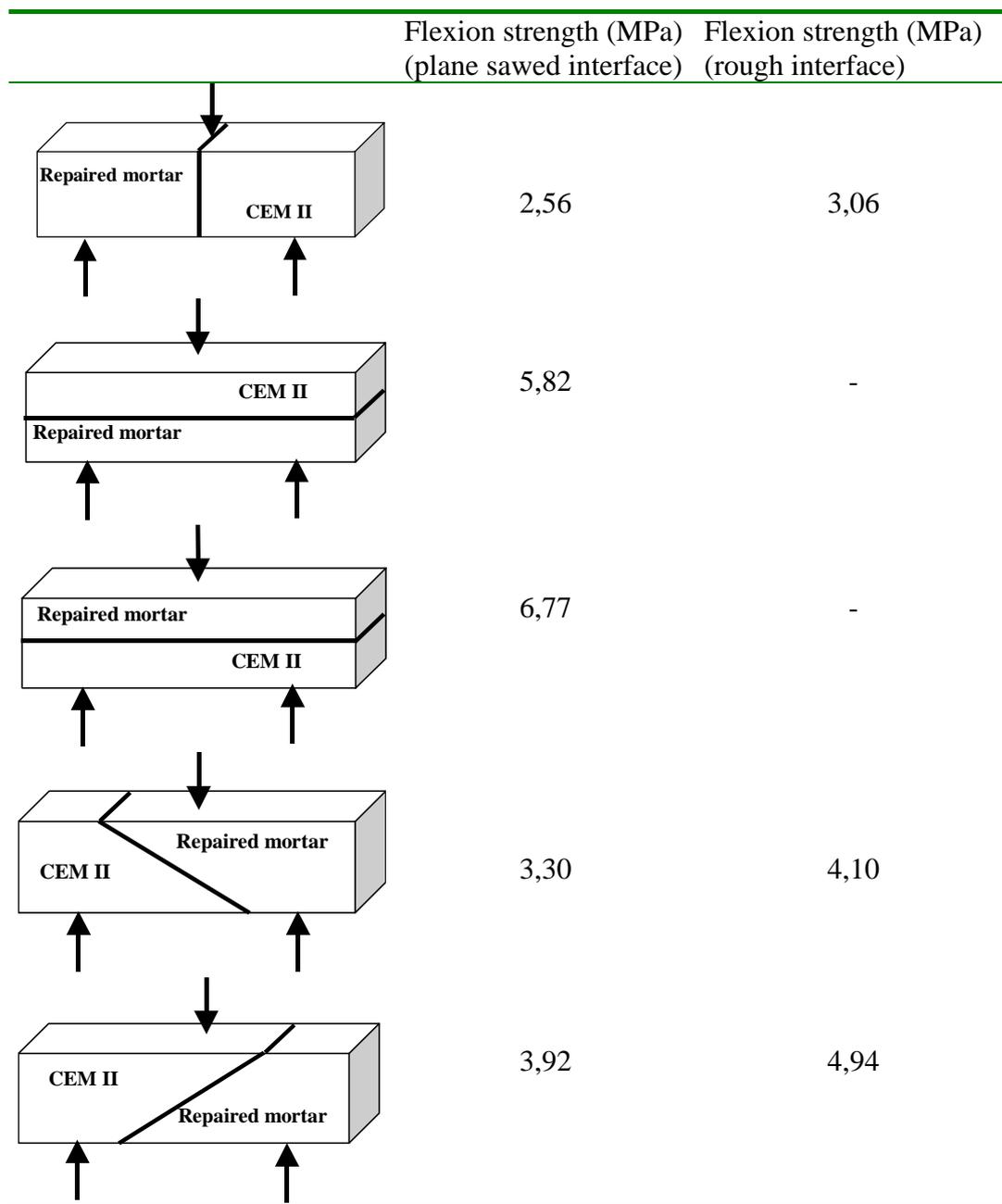


Figure 2: Flexion strength of repaired mortar

Finally, the figure 2 allows one to compare the flexion strength for a two series of samples:

- the first one for which the reparation plan has been sawed (smooth interface)
- the second one for which the reparation plan has been prepared by breaking (rough interface)

The obtained values confirm the previous results and show that the flexion strengths are largely higher in the case of rough interface. In the case of an inclined reparation plane, the measured flexion strengths are close to the one observed for the phosphate binder.

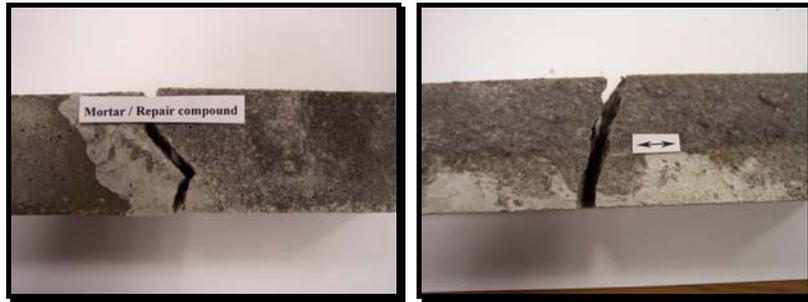


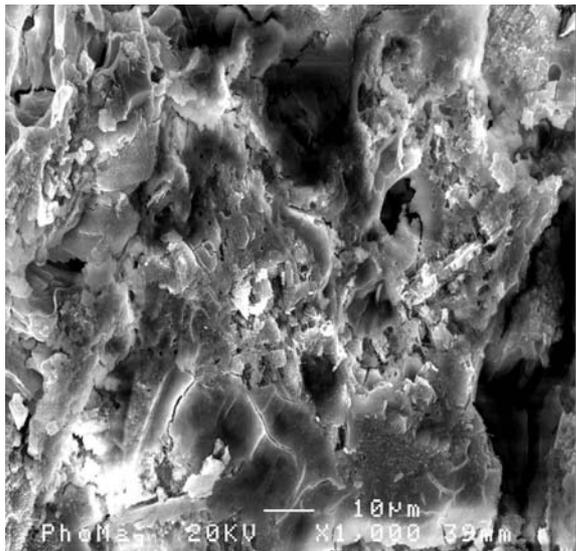
Figure 3: Rupture modes (lower face under tension)

SEM OBSERVATION OF THE RUPTURE PLAN

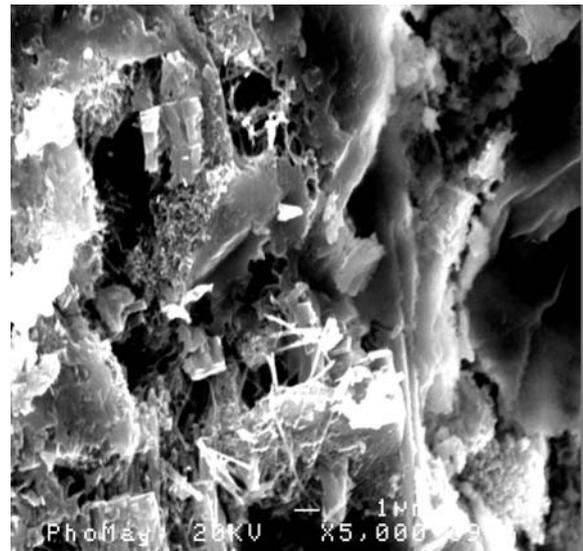
The SEM view of the rupture plan is represented on Figure 4. The breaking occur inside the phosphate binder phase, this being confirmed by the X-ray microanalysis. Figure 4 almost describe the whole rupture surface. The figure 4b has been realized on one of the very rare area where Portland cement is detected: the fibrous compound is made of ettringite and the porous area corresponds to the CSH. Figure 3c shows well shaped mineral phase but slightly altered, as can be seen on Figure 3d. This can be explained by a very pH due to the Portland cement (ca. 12 for Portland cement) whereas the pH of the phosphate binder is lower (ca. 7).

CONCLUSION

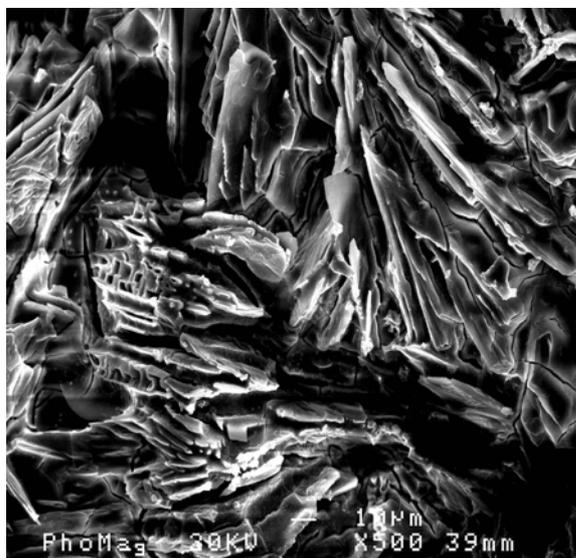
We have shown in this study that it was possible to use a phosphate binder as a reparation mortar. The very short and adjustable setting time dramatically reduce the closing of premises, buildings and workmanship. Compared to Portland cement based reparation mortar or concrete, the closing would be several days long. Even if the mechanical strength are slightly lower than for Portland mortar or concrete, these type of phosphate binder should better resists acidic attacks because of its quite low pH. The adhesion between those phases (phosphate binder and Portland cement mortar) is quite correct as far as, when the surface to be repaired is rough, the breaking occur in the phosphate binder and not at the interface. This means that, before any reparation with type of phosphate binder, the surfaces will have to be scratched in order to create roughness. The phosphate binder crystallized phases at the interface are very dense and only a few points seem to be more fragile.



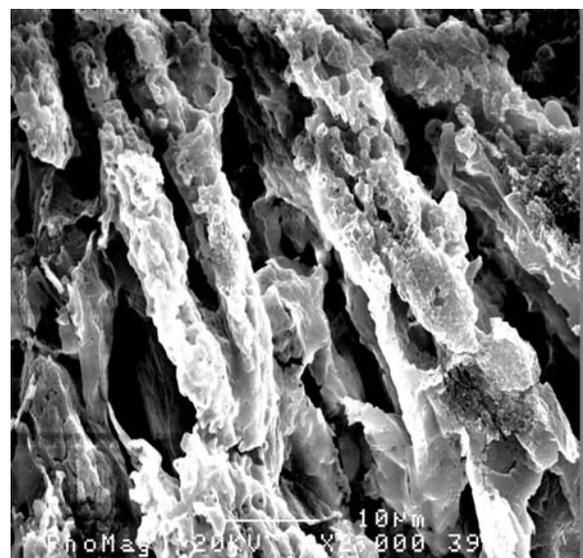
a (x 1 000)



b (x 5 000)



c (x 500)



d (x 2 000)

Figure 3: SEM observation of the rupture plan.

¹ 'Concrete Solutions', 1st International Conference on Concrete Repair, Saint Malo France, 15 – 17 july, Editors : M. Grantham, F.Rendell, R. Jauberthie, C. Lanos, GR Technology Ltd, London, UK. 2003.

² 'La Détérioration des Matériaux de Construction', International Symposium, La Rochelle France, 12 – 14 juin, Editeur : F. Auger, La Rochelle, France, 1991.

³ 'La Dégradation des Bétons', J. M. Torrenti, O. Didry, J. P. Ollivier, F. Plas, Hermes Sciences Publications, Paris, France, 1999.

⁴ 'Deteriorated Concrete, Inspection and Physico Chemical Analysis', F. Rendell, R. Jauberthie, M. Grantham, Editor : Thomas Telford Ltd, , London, UK. 2002.

⁵ 'Réhabilitation du Béton Armé Dégradé par la Corrosion', Documents Scientifiques et techniques de l'Association Française de Génie Civil, Novembre 2003.