Materials Science and Technology

Edited by
Ping He and Jongee Park

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Materials Science and Technology

Selected, peer reviewed papers from the
2014 2nd International Conference on
Advances in Materials Science and Engineering
(AMSE 2014),
October 1-2, 2014, Dubai, UAE

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Preface

It is our pleasure to welcome you to the 2014 2nd International Conference on Advances in Materials Science and Engineering (AMSE 2014) will take place on October 1-2, 2014, Dubai, UAE.

The conference program covered invited, oral, and poster presentations from scientists working in similar areas to establish platforms for collaborative research projects in this field. This conference will bring together leaders from industry and academia to exchange and share their experiences, present research results, explore collaborations and to spark new ideas, with the aim of developing new projects and exploiting new technology in this field.

It is gratifying that the proceeding of AMSE 2014 include more than 40 excellent papers selected from more than 100 submitted paper(s) whose authors involved at least 9 countries and areas such as Slovakia, Nigeria, Algeria, Romania, Russia, Morocco, Japan, Egypt, and India.

Putting together a coherent program of the highest possible quality has not been an easy task. We would like to thank the organization staff, the members of the program committees and reviewers. They have worked very hard in reviewing papers and making valuable suggestions for the authors to improve their work. Special thanks go to the organising committee, program committee members, and TTP Publisher. Finally, the conference would not have been a success without the support of the authors. We would like to acknowledge and thank all authors who submitted their research work to the conference, whether the submission made it to the proceedings or not.

We hope that AMSE 2014 will be successful and enjoyable to all participants. And all attendees of AMSE 2014 have an enjoyable scientific gathering in Dubai, UAE. We look forward to seeing all of you next year.

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CHAPTER 1:

Materials Science and Technology

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Deterioration of Mortar Composites in Acidic Environment

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Abstract. In recent years, the rapid deterioration of various reinforced concrete structures has been widely recognized as worldwide problem. Acidic environments are very aggressive to concrete structures, as well as promote their degradation. The aim of this experimental study is to make a comparative analysis of the behavior of mortars prepared by cement (CPJ-CEM II/A) and composites of different percentage by weight of polymer. It highlights the influence of PET on the durability of these mortars. After 28 days of curing specimens in water, they are put in acid solutions of the same concentration 3% (HCl, H_2SO_4, H_3PO_4 and HNO_3). Weights tests measuring are made at different ages. The results demonstrate the beneficial effect of the addition of PET in the modified materials against chemical attack by various acids. The formations which appear such as different calcium salts were determined by X-ray diffraction. These results take into account the recycling of plastic waste in the manufacture of modified mortars against aggressive environment.

Introduction

Concrete or mortar binding components are susceptible to chemical attack by acids. According to Pavlík [1,2], all hydrated cement compounds are stable only in solutions with well defined ranges of concentrations for Ca^{2+}, OH^- and sometimes minor ions as well. It is well known that as the pH of the solution decreases, the constituents of the hardened cement paste are essentially altered by decalcification [1,4].

Pavlík [1] has shown that the rate of corrosion of cement paste in acids giving easily soluble Ca-salts depends to a large extent on the acid's dissociation constants. The aggressive effects of strong and weak acids differ whenever they are compared at equal concentrations or pH-values.

In order to highlight the behavior of mortars and composites in aggressive environments, we conducted a series of chemical tests, according to Ohama [5] and Benosman et al. [6].

The tests were carried out on mortars containing CPJ-CEM II/A cement obtained from Zahana factory, of which a part has been replaced by adding a polyethylene terephthalate (PET), the percentage of substitution is 2, 4 and 6% by weight of cement and that for each addition. To study the resistivity of these mortars against various acid solutions, we wanted to keep the same water / cement ratio for all compositions of mortar (w/c = 0.5).

The purpose of this substitution is to see the effect of PET polymer, which is a waste material obtained by crushing of used PET bottles, on the characteristics of durability and behavior of mortars under immersion in test solution with 3% HCl, 3% H_2SO_4, 3% H_3PO_4 and 3% HNO_3. Their acid behavior is discussed by measuring weight change at different ages. The formations which appear on the surface of the samples were analyzed by X-ray diffraction.

Materials and Methods

We have used normal mortars, according to the standard NFP 15-403 [7], the composition is as follows:

- 450g binder, an additions still being introduced as a substitute for cement;
- 1350g of the crushed sand of Kristel quarry in Oran.

This corresponds to a sand/cement ratio equal to 3. The rate of mixing water has been kept constant for all the mortars: w/c = 0.5.

Characterization of fresh mortars. The characteristics of the fresh mortars are shown in Table 1.

Table 1. Mix proportions and basic properties of the materials studied.

Mortar/Composite	*Mix design*	*Addition (%^{w})*	*Flow test (cm)*	*W/C*
CPJ-CEMII/A	CPJ or PET0	0.0	12.5 -13.5	0.5
CPJ-CEMII/A + PET	PET2	2.0	12 - 13	0.5
CPJ-CEMII/A + PET	PET4	4.0	12 - 12.5	0.5
CPJ-CEMII/A + PET	PET6	6.0	11.5 - 12	0.5

Resistance to Acid Attack Test. The relative acid attack was determined in accordance with ASTM C-267-03 [8]. The mortar specimens were cured in water at 20 ± 1°C for 28 days before being subjected to acid attack. Three specimens of each mortar and composite mixes (40x40x50 mm^3) were immersed in four types of chemical solutions: 3% hydrochloric acid (HCl), 3% sulfuric acid (H_2SO_4), 3% phosphoric acid (H_3PO_4) and 3% nitric acid (HNO_3). The weight change of specimens was examined after different ages of immersion. Before the test, the attacked specimens were cleaned with deionised water and then the mass loss (*ML*) of the specimens was calculated by the following equation:

$$ML(\%) = \frac{M_r - M_s}{M_r} \times 100 \qquad (1)$$

Where M_r is mass of the specimen before immersion and M_s is mass of the cleaned immersed specimen after test period. The solution was renewed every 7 days.

Results and Discussion

Figs. 1 and 2 show the test results of weight change versus time for mortar and composites specimens exposed to 3% HCl, 3% H_3PO_4 and 3% HNO_3 solutions for 28 days and 3% H_2SO_4 solution for 35 days.

HCl attacks hardened mortar through a dissolution process, forming hydrate calcium chloride which is a soluble salt ($CaCl_2.2H_2O$); leaching also takes place. So, before the 7th day of immersion in 3% of HCl, no effect of the addition of PET in modified mortars is observed. After this period the PET6 increases it ability to resist acid attacks. So, after 28 days exposure to HCl solution, for the PET-composites, the mass losses are lower than the corresponding PET0 mortar by 2.38%, 4.68% and 8.55%, respectively (Fig. 1a).

After 28 days of immersion, the mass loss for the PET0 mortar is around 34.61 %, 20.25 % and 17.1 % in HCl, HNO_3 and H_3PO_4, respectively, and about 10.19% in 3% H_2SO_4 after 35 days (Figs. 1and 2) .

The incorporation of 6% polyethylene terephthalate (PET6) reduced mass loss about 8.55% in HCl, 10.19% in H_2SO_4 (after 35 days), 3.75% in HNO_3 and 1% in H_3PO_4 acid solutions when compared to the CPJ control mortar (Figs. 1 and 2).

After 28 days of immersion in 3% H_2SO_4 acid, it was observed that the composite PET4 reduced weight loss of 10% and the composite PET6 reduced weight loss of 2.5%. But, at 35 days, one noted a reduction about 10.19% and 8% for PET6 and PET4, respectively (Fig. 1b).

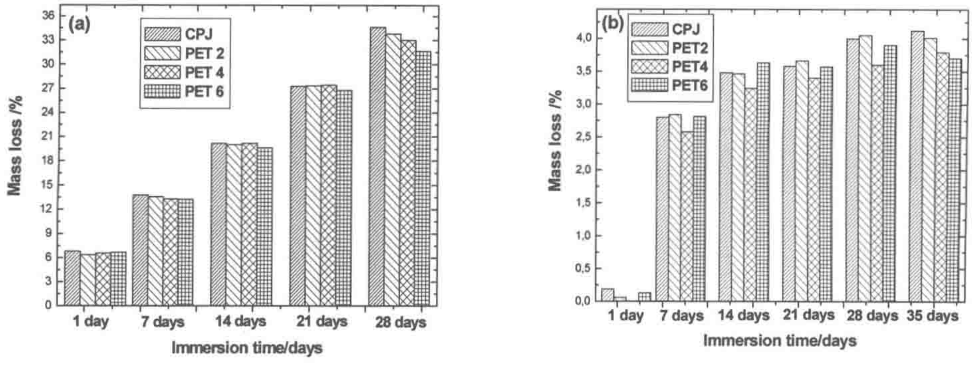

Fig. 1. Mass loss of specimens under: (a) hydrochloric acid and (b) sulfuric acid exposure.

However, at 28 days of exposure to H_3PO_4 solution, for the composites PET2, PET4 and PET6, the losses in weight are lower than the CPJ mortar by 7.37%, 5.2%, and 1% respectively, (Fig. 2a).

One can also noted, after 28 days of immersion in 3% HNO_3 solution, there is a reduction of 3.75% for PET6, and 0.80% for PET4 compared to CPJ control mortar (Fig. 2b).

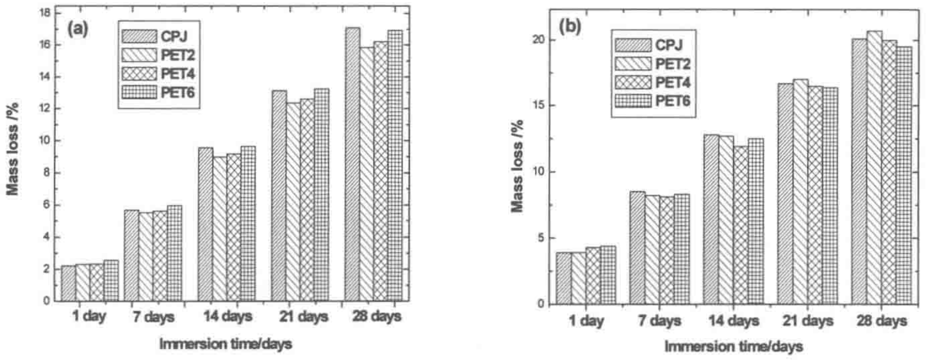

Fig. 2. Mass loss of specimens under: (a) phosphoric acid and (b) nitric acid exposure.

The Fig. 3 shows the effect of acid attack on different mortar and polymer-mortar composites after 28 days of immersion. One sees for all specimens, that the mass losses due to the hydrochloric acid are greater than those due to other acids.

The CPJ control mortar shows that the weight loss due to the solution of:

- ✓ 3% of H_2SO_4 is less than 88.44% with respect to the 3% HCl solution.
- ✓ 3% H_3PO_4 is 50.60% lower compared with the 3% HCl solution.
- ✓ 3% HNO_3 is less than 41.50% with respect to the 3% HCl solution.

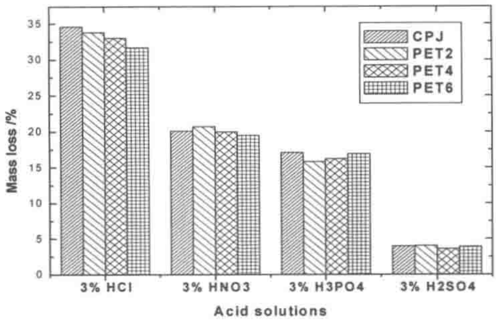

Fig. 3. Mass loss of specimens under various acidic exposures at 28 days.

Consequently, the chemical resistance of materials is more or less affected by the concentration and the nature of acids in the order with the most aggressive as given below:

$$HCl > HNO_3 > H_3PO_4 > H_2SO_4 \text{ (at 3\%)}.$$

The incorporation of organic additions (polymers) increases chemical resistance in aggressive media. This is confirmed by other research teams [9, 10].

The decrease in porosity due to the incorporation of PET in modified mortars [11] contributes to reduce the absorption of acidic solution accompanied by a reduction of loss in weight. So, this study demonstrates that the addition of PET polymer has a positive effect on the resistance of polymer-mortar composites against acid attacks.

These results are confirmed by the change of surface samples before and after immersion in the aggressive solutions as depicted in Fig. 4. According to ASTM C267-03 [8] and the recently published papers [9,10,12], the resistance of specimens to acid attack is judged only by consideration of mass loss.

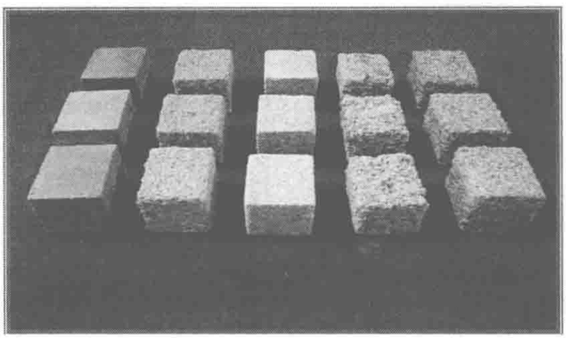

Fig. 4. Immersion of the polymer-mortar composites in: 1-tap water; 2- HCl, 3- H_3PO_4, 4- HNO_3 and 5- H_2SO_4 at 3% respectively for 28 days (From the left to the right).

The increase in the resistance to acid attacks of the composites is attributed to the impervious PET granules blocking the passage of the aggressive ions. These results are in agreement with those reported by Benosman et al. [6], and Kou et al. [13]. Furthermore, according to Benosman et al. [14] PET polymers makes the cementing matrix denser and reduces the porosity of the hardened paste.

In general, the chemical attack tends to decrease with increasing polymer-cement ratio. It is also obvious from the above data that the composites are generally superior to the unmodified mortar in the resistance to acidic penetration. In addition, our results are in agreement with those reported by Benosman et al. [6].

Mortar Composites modified with PET waste are often used as low-cost materials for preventing chemical attacks or repairing various reinforced concrete structures damaged by chloride-induced