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Study of Chloride Ion Transport of Composite by Using Cement and Starch as a Binder

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Abstract. This study presents the chemical bonding and the structural properties of composites from accelerator chloride test migration (ACTM). The volume fractions between binder (cement and starch) and charcoal in composites are 20:80 and 60:40. The effect of the binder to the chemical composition, chemical bonding, and structural properties before and after chloride ion passing through the composites was determined by X-ray fluorescence (XRF), by Fourier transform infra-red (FTIR), and x-ray diffraction (XRD), respectively. From the XRD data, XRF data, and the FTIR data shows the amount of chemical composition, the type of binding, and the structure of composites are depending on the type of binder. The amount of chloride migration using starch as binder is higher than that of cement as a binder due to the density effects.

Keywords: Composites, Chloride, XRF, FTIR, XRD.
PACS: 81.05.U-, 87.64.Bx, 87.64.Cc, 88.30.mj

INTRODUCTION

Reinforce composite structures are exposed to harsh environments with expected with little or no maintenance for long periods of time [1]. For example are reinforced composite concrete bridges. One of the major forms of environmental attack is chloride ingress which leads to corrosion on reinforcing steel in the bridges [1,2]. The corrosion will reduce the strength of the structure. The ability of chloride ions to penetrate the composite must be known for quality control purposes as well as design in the structure. Chloride migration test were developed to obtain the chloride diffusion coefficient in a much shorter test period compared to natural diffusion tests [2-4].

In this study we have designed a simple chloride migration test called ACTM and apply for composite based activated charcoal from biomass material by using cement and starch as binder. Charcoal is light material and the atom are easily bonding with chloride ion. We have compared two type of binder to understand the influence of the binder in accelerate the chloride in composite. We have used X-ray fluorescence spectroscopy (XRF) to determine the amount of chloride in composite material, FTIR to determine the chemical bonding between matrix (cement and starch) and charcoal as well, and XRD use to determine structural properties of sample after applying in ACTM. By the simple design of ACTM, the chemical composition, the chemical bonding, and the structural characteristic before and after applying in ACTM of the composites were studied and compared.

EXPERIMENT

Composites in this study are compound between charcoal and binder (cement and starch) with water/composite ratio was 0.45. Mass ratio between charcoal and binder was varied (0%, 20%, 60%) in order to understand the

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influence of charcoal and binder on the chloride migration of composites. We have used name of composites based on the ratio of binder and charcoal as follows:

C2C8 for 20 % of cement and 80% of charcoal,
C6C4 for 60% of cement and 40% of charcoal,
S2C8 for 20% of starch and 80% of charcoal, and
S6C4 for 60% of cement and 40% of charcoal.

The accelerated chloride migration test (ACTM) was developed to obtain the accumulative concentration of chloride ions passing through the sample under 24 voltages. Schematic diagram of ACTM is shown in Fig.1. The sample were coated with epoxy and placed between two electrodes and two acrylic cells. Electrical fields were connected to a 30 V DC power source in which the distilled water electrode is the anode and the 3% NaCl electrode is the cathode. The anode was filled with 1000 ml distilled water and cathode was filled with 1000 ml NaCl. The amount of chloride in the sample was measured by using XRF.

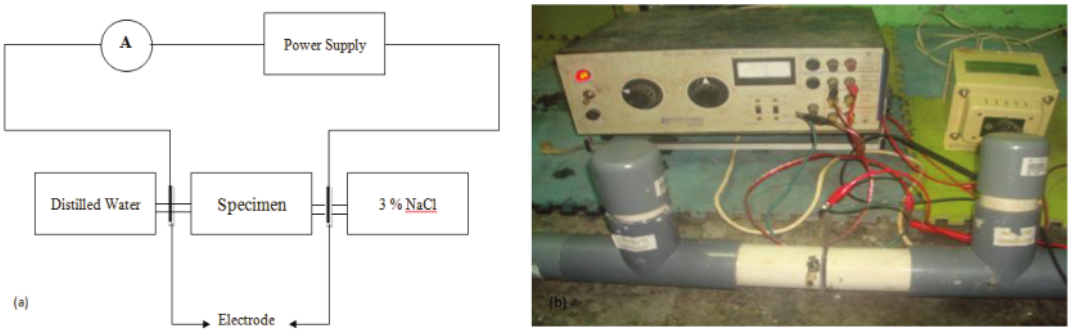

FIGURE 1. Schematic diagram of: a) ACTM and b) ACTM during tested

RESULT AND DISCUSSION

Chemical composition of the composites before and after applying in ACTM was determined by using XRF. XRF usually use to determine the chemical composition in many field such as; in geology, in archeology, in pharmacy, in biology, in physics, and in environment. In this study, we use XRF to determine the chemical composition of composite, as can be seen in Table 1. The Ca and Si is the main chemical in the composites with cement as a binder and Ca and K in composites with starch. XRF shows for composites before applying in ACTM shows there is no chloride. The significant amount of chloride ion are >50% for the composites with starch after applying in ACTM. For cement as a binder the compositions of the chloride ion are not significantly change when the cement is increase. The amount of chloride ion in the sample is depending on the type of binder. Starch binder shows higher absorb chloride compared with sample using cement as a binder. The change in the composition shows the effect of binder were influence to the chemical composition may due to ability of the binder in a bonding with the atom of the host. Atom in starch probably doesn't match with the atom in activated charcoal, which is produce pore in composite material [5, 6].

To obtain more information the effect of chloride to the chemical bonding of composites, we have determined through the absorption bands by FT-IR spectroscopy as can be seen in Figure 2. The amount of molecules involved in the composite is directly correlated with the intensity of the absorption band [4]. It can be seen that in Fig. 2 the absorption band of hydroxyl group (-OH) at 3450 cm^{-1} for composite with starch are broad than composite with cement. This condition is suggested that the starch gets more involved in the formation of hydrogen bonding. Most of the band in composite such as formation of alkanes (C-H stretch) at 2931 cm^{-1}, alkenes (-C=C-) at 1643 cm^{-1}, nitro compound (N-O) at 1343-1460 cm^{-1}, alkyl halides (-CH2X) at 116 cm^{-1} 3, and carboxyl acids (O-H bend) at 999 cm^{-1} indicate the present of the starch and only band from nitriles (C#N) at 2344 cm^{-1} for charcoal. Composite by using cement as binder shows less peak compared with starch as binder. The main peak for composite with cement shows hydroxyl group at 3450 cm^{-1}, alkanes (C-H band) at 1420 cm^{-1}, and aromatic (C-H) at 873 cm^{-1} is come from cement peak and small peak from nitriles at 2344 cm^{-1} shows the presence of charcoal. The binder gives a strong effect to the chemical bonding as can be seen clearly in Fig. 2, which is shows dominant peak from the

binder in the composites. From the intensity and the broadening of FTIR spectra shows the small effect of the starch to the bonding formation in composite event the composition was increase from 20% to 60%. For composite with cement shows the intensity was decrease with increasing the amount of cement in composite due to the bonding formation was change. As can be seen in Fig. 2 the effect of chloride after the composite applied in ACTM shows the intensity and the broadening of the peak was change significantly for composite with cement compared with composite with starch [4].

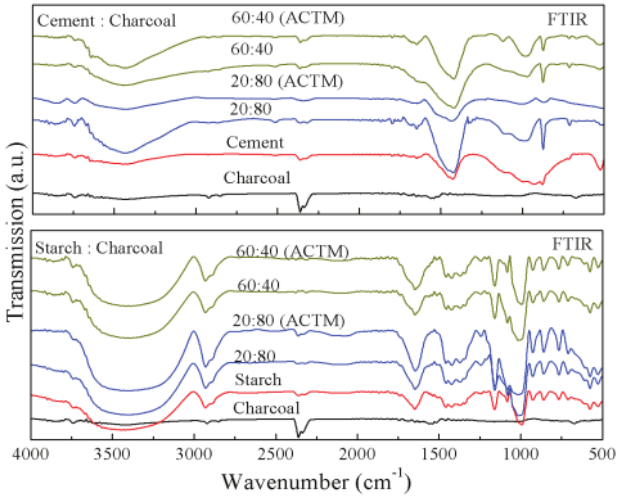

FIGURE 2. FTIR spectra of composites, starch, cement and charcoal

Figure 3 shows the XRD result for starch, charcoal, cement and composites. XRD spectra shows two phase (amorphous and crystalline) of the composite. The amorphous phase indicated by the broad peak as can be seen for starch and at low 2θ (<30 degree) for charcoal. For composite by using starch as a binder shows amorphous phase is dominated. For cement and composite by using cement as a binder shows the crystalline phase is dominated as can be seen in Fig 3. XRD spectra shows the strong effect of the binder (starch and cement) in the composite. The compositions of the binder are 20% and 60% in the composite. The peak formation in the composites shows significant contribution from the binder in the composite. The XRD spectra shows similarity for the binder 20% and 60% in composites, indicated there is no effect of the amount of the binder to the structural properties of composites.

TABLE 1. Chemical composition from XRF for composites before and after chloride migration.

Chemical Composition	Composites (Cement) Weight (%)	Composites (Starch) Weight (%)	Composites C2C8 ACTM (Cement) Weight (%)	Composites C6C4 ACTM (Cement) Weight (%)	Composites S2C8 ACTM (Starch) Weight (%)	Composites S6C4 ACTM (Starch) Weight (%)
Ca	74.93	61.80	65.06	79.57	19.78	29.41
Si	14.18	-	4.90	7.35	-	-
Fe	7.50	-	8.11	9.35	-	-
K	2.72	36.48	1.53	1.14	19.49	24.27
Cl	-	-	6.67	1.76	57.08	45.68
LOI	0.67	1.72	13.73	0.83	3.65	0.64

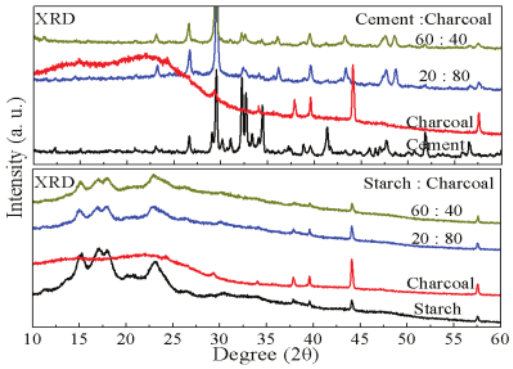

FIGURE 3. XRD spectra of composites

CONCLUSIONS

In this work, we determined the effect of binder to the chemical bonding, composition and structural properties of composites after applying in ACTM analysis by FTIR, XRF, and XRD, respectively. The chemical bonding from FTIR shows the effect of chloride after the composite applied in ACTM shows the intensity and the broadening of the peak was change significantly for composite with cement compared with composite with starch. From XRF data shows the amount of chloride ion in the sample is depending on the type of binder. Starch binder shows higher absorb chloride compared with sample using cement as a binder. Analysis XRD shows the peak formation of the composites significantly contribution from the binder. The main peak of XRD shows unchanged significantly with increasing the amount of binder up to 60% indicates small effect of composition of the binder. For the next study we will apply the ACTM for the reinforced composite concrete.

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