The Effect of Effective Microorganism (EM) Inclusion to the Setting Time of Microbed Cement Paste

Noorli Ismail[1,*], *Hamidah* Mohd Saman[2], *Mohd Faizal* Mohd Jaafar[3], and *Siti Radziah* Abdullah[1]

[1]Faculty of Civil and Environmental Engineering, Universiti Tun Hussein Onn Malaysia, 86400 Parit Raja, Batu Pahat, Johor, Malaysia
[2]Faculty of Civil Engineering, Universiti Teknologi MARA, 40450 Shah Alam, Selangor, Malaysia
[3]Faculty of Civil Engineering and Earth Resources, Universiti Malaysia Pahang, 26600 Pahang, Malaysia

Abstract. The inclusion of Effective Microorganism (EM) lengthen the setting time of microbed cement paste with respect to the control cement paste. However, the investigation on the influence of EM ingredients to the setting time was not performed yet in the earlier study. Therefore, the test of X-Ray Diffraction (XRD) was performed on the EM product used in order to determine their ingredients. Further examination was carried out to analyse the pore characteristics in examining the effect of the pore size distribution to the setting time of microbed cement paste. Potassium Chloride (KCl) was detected in EM liquid using XRD test. It can be concluded, the ingredient of EM which is consist of the molasses influenced the setting time of microbed cement paste. The hardening rate of microbed cement paste was effected by the presence of KCl. The pore size of microbed cement paste recorded the lower pore volume (mL/g) with respect to the control cement paste. The larger intrusion of mercury was recorded at smaller pore diameter in microbed cement paste while control cement paste occupied at the bigger pore diameter. The microbed cement paste (16.5%) recorded the smaller porosity than cement paste without EM (20.3%). The smaller cement pore effects the delayed setting time of microbed cement.

1 Introduction

Increasing of concrete consumption introduces the processed and unprocessed product materials or waste materials in the concrete mix to improve the concrete workability, durability and mechanical properties. The significant outcome by adding these materials are well reported [1-15]. Beginning of the 21th century, other new potential materials have been initiated to enhance the cement based properties is Effective Microorganism (EM) [16-24]. The incorporation of EM in cement paste prolonged the initial and final of setting time. Due to the extended setting time, its effect the process of hydration of microbed

* Corresponding author: noorli@uthm.edu.my

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cement paste [21]. The decrement pore size of cement paste particles also lengthen the setting time [25].

However, the study was not published yet in examining the effect of EM ingredients to the delayed setting time of microbed cement paste. Furthermore, the outstanding result performed in previous studies [16-24] initiated the curiosity to carry out further experiments to study the effectiveness of EM in analysing the pore size of microbed cement paste. Therefore, this present study was carried out to investigate the influence of EM inclusion to the setting time of cement paste. Vicat test was performed on the cement paste containing with and without EM. The X-Ray Diffraction (XRD) was carried out in investigating the ingredients of EM liquid while total porosity, total pore area and diameter, their distribution and average were determined to relate the pore characteristics to the setting time of cement paste by performing the Mercury Intrusion Porosimetry (MIP) test.

2 Experimental

The Effective Microorganism (EM) was obtained from Johor Farmers' Organisation, Malaysia. One (1) litre of mixtures consist of distilled water (90%) and EM (10%) was named as Effective Microorganism Solution (EMS). Seven (7) days of fermentation was carried out in plastic bottle to activate the microorganism growth in mixtures. The pH of the mixtures was less than four (4) before being added into the cement paste. The test of Vicat and Mercury Intrusion Porosimetry (MIP) were performed on the microbed and control cement paste while the liquid of EM used was tested using X-Ray Diffraction (XRD). The following subsection describes the preparation of cement paste and testing required.

2.1 Preparation of cement paste

The quantity of water required was calculated from the consistency test which was 28% and 30% recorded in control and microbed cement paste, respectively. The cement paste of 500g was blended with 140ml of distilled water and 150ml of EMS. The size of mould prepared was 50mm and the specimens leave in the room temperature before tested by MIP.

2.2 Consistency and setting time

The cement paste of 500g mixed with 100ml of distilled water and EMS. The plunger of Vicat released at 4min ± 10s after zero time. The penetration was recorded with different water amounts until the distance of plunger and base-plate reached at 6 ± 2 mm. After achieved the consistency of paste, the plunger was replaced by the needle. The needle of Vicat adjusted and reached the surface of the paste. The initial setting time was measured at zero time when the needle released to the time at which the needle penetrates vertically into the paste when the distance reached 6 ± 3 mm between the needle and the base plate. The final setting time determined when the time elapsed was recorded from zero to the time at needle finally penetrates only 0.5 mm into the paste [26].

2.3 X-Ray diffraction (XRD)

XRD test was carried out at Faculty of Pharmacy, Universiti Teknologi MARA (UiTM), Puncak Alam, Selangor with scanning from 2º to 90°. The liquid of EM was put on the specimen's holder before placed at tubular aerosol suspension chamber.

2.4 Mercury intrusion porosimetry (MIP)

The equipment of Micromeritics AutoPore IV was used to obtain data of porosity, pore characteristics and their distribution. The test was performed at the Multipurpose Laboratory, Faculty of Chemical Engineering, Universiti Teknologi MARA (UiTM), Selangor. The crushed of cement paste specimens was tested at the age of 3, 14 and 28 days of curing period. The test was carried out by applying a pressure between 0.1 MPa and 400 MPa.

3 Results and discussion

The results of cement consistency and setting time, XRD and MIP of cement paste with and without Effective Microorganism (EM) was described in the following sections.

3.1 Effective microorganism (EM) inclusion influence the cement consistency and setting time

The inclusion of EM in the cement paste increased the cement consistency and setting time. The cement consistency recorded was 28% and 30% in cement paste without EM and with EM, respectively. In control cement paste, the initial setting time recorded at 45 minutes while final time set at 145 minutes. Initial setting time of microbed cement paste indicated at 55 minutes while final in 170 minutes.

3.2 Effective microorganism (EM) ingredients influence the delayed setting time of microbed cement paste

The analysis of XRD in Fig. 1 shows the liquid of Effective Microorganism (EM) used in this present study contains high potassium chloride (KCl). Generally, KCl is a mineral used as fertilizers by farmers in plantation. This mineral is widely used as main ingredients in sugar which was commonly found in sugarcane [27]. The contents of KCl in EM used was confirmed by the addition of molasses in this present study. The molasses used in this study was produced from the sugarcane. The presence of KCl in EM influence the hardening rate of microbed cement paste which was lengthen the setting time of microbed cement paste [20]. The similar pattern found in the previous study [27-29] also concluded that molasses contents influenced the setting time of cement which was acted as retarder in the cement paste.

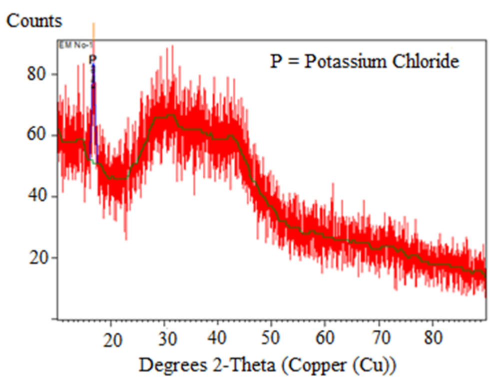

Fig. 1. Potassium chloride (KCl) detected in EM liquid

3.3 Effective microorganism (EM) inclusion influence the pore size and porosity of cement paste

The pore volume (mL/g) against pore size of control and microbed cement paste obtained from Mercury Intrusion Porosimetry (MIP) tests can be referred to Fig. 2 and Fig. 3. The test was performed on the curing day of 28. Generally, the pore diameters of all specimen displays a size more than 1μm. The curves is located at the larger pores region. The pore volume of microbed cement paste slightly lower compared to the cement paste without EM as shown in Fig. 2. In microbed and control cement paste, the larger mercury intrusion presented at pore diameter started from 20μm to 40μm and between 40μm and 50μm, respectively. The smaller of pore size and lower pore volume delayed the setting time of microbed cement. So it is consistent with larger mercury intrusion at range between 40μm and 50μm.

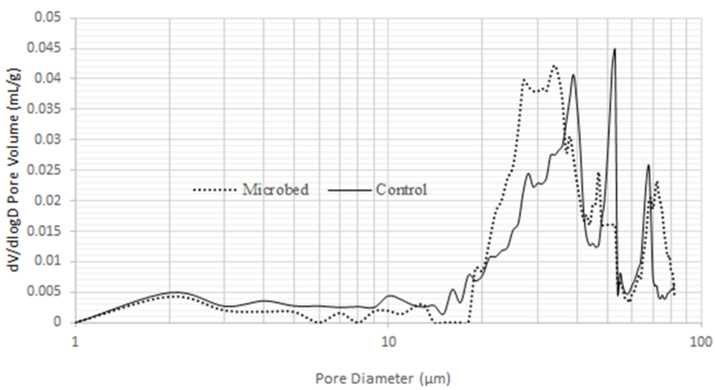

Fig. 2. Pore size distribution of control and microbed cement paste

The pore volume and diameter of microbed cement paste in Fig. 3 shows the highest pore volume found in the specimens of three (3) days with more than 0.12 mL/g. This can be due to the delayed setting time which reduced the hardening rate of the microbed cement paste. The pore diameter decreases with respect to the increment of curing days. In average, the larger mercury intrusion occurred at pore diameter between 20μm to 40μm in all specimens of microbed cement paste.

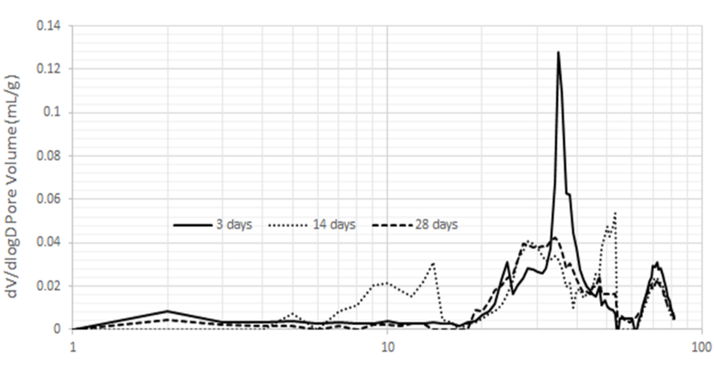

Fig. 3. Pore volume with respect to pore diameter of microbed cement paste

Table 1 presents the microbed cement paste having the reduction of total porosity (16.5%) than the control cement paste (20.3%) while median pore diameter represents the point that located 50% of pore size distribution curve. In microstructure examination found the densification matrix of microbed cement paste was denser and less voids with respect to the control paste without EM [20, 22]. The micrograph image captured was consistent with the result of porosity and median pore diameter. The microbed cement paste presents smaller value of median pore diameter corresponding to control cement paste. The maximum and minimum pore diameter do not show significance effect to the setting time of cement. Rationally, these two (2) data do not correlate to the pore volume of cement paste unless the graph of logarithm was constructed.

Table 1. The pore characteristics of control and microbed cement paste at the age of 28 days of curing

	Control	**Microbed**
Total porosity (%)	20.325	16.492
Average pore diameter (μm)	0.0539	0.0206
Median pore diameter (μm)	0.2424	0.0154
Maximum pore diameter (μm)	319.057	319.163
Minimum pore diameter (μm)	0.00301702	0.003017

4 Conclusion

The ingredient of Effective Microorganism (EM) used as the addition in the cement paste showed the presence of Potassium Chloride (KCl) which was detected using X-Ray Diffraction (XRD) test. Consequently, the setting time and hardening rate of microbed cement paste was effected by the presence of KCl due to the existence of molasses in EM liquid.

The addition of Effective Microorganism (EM) into the cement paste decreased the porosity with 19% corresponding to the control cement paste at the age of 28 days curing. The larger mercury intrusion occurred in microbed cement paste at pore diameter between 20μm and 40μm at the age of 28 days curing. The decrement of pore size delayed the setting time of cement. It can be referred to the result of lower pore volume and smaller pore diameter indicated in microbed of cement paste. The larger pore size recorded when the larger mercury intrusion at range between 40μm and 50μm in cement paste without EM.

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