The Effect of Different Concentration Sodium Hydroxide Treatment of Oil Palm Empty Fruit Bunch Fibre on Surface Morphology and Cement-EFB Fibre Hydration Rate

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ABSTRACT

Due to rapid growth of construction activities in the world, the demand of construction materials has been increased. To resolve the issues, wide research attempts has been made to convert the agriculture waste to construction material. Among the agriculture waste, Empty Fruit Bunch Fibre (EFB) from the oil palm industry has been proven to improve certain performance of the cement when it is added to the cement. The use of EFB-cement composite is limited due to incompatibility as the fibre extractives inhibited the cement setting and hydration. This paper highlights the effect of EFB fibre pre-treatment to the change of fibre surface morphology and the rate of EFB-cement hydration. In this research, EFB fibre was soaked in Sodium Hydroxide (NaOH) with the concentration from 0.2% to 8% for 24 hours before it was mixed with the cement. It was found that reduction percentage of silica body from EFB fibre due to NaOH treatment, significantly influenced the hydration rate of EFB-cement composite. Based on the results, untreated EFB fibre with numerous silica body has proven to inhibit cement hydration due to its lowest hydration temperature. The increase of NaOH concentration clearly reduce the existence of silica body from EFB fibre and increased the hydration temperature of EFB-cement composite. It was observed that the silica body completely removed from the fibre strand started at 2% NaOH concentration at 37°C to 44.5°C. The results implied that EFB fibre can be used as cement–fibre product with pre-treatment to enhance the compatibility between EFB fibre and cement.

KEYWORDS: Agriculture waste, EFB fibre, Hydration temperature, Pre-treatment, Cement.

1. INTRODUCTION

The natural fibre-cement composites (NFCC) have been used in the construction industries as a part of material for more than 60 years. The utilization has promising several improvements for cement composites products such as, reduce brittleness of cement through products strength

Nowadays, most of production of NFCC made of wood. Thus, due to rapid decreasing of wood resources along with economy development and uncontrollable deforestation activity (NTIP 2008; Wei et al. 2002), the utilization of wood resources need to be minimize. NFCC products source of wood, have to be replace with other lignocellulosic fibres. Such as oil palm empty fruit bunch fibres (OPEFB) that are readily available within the Malaysia.

OPEFB is the fibrous mass that left behind, after the oil extraction from fruit and fresh fruit bunch (FFB) in oil palm mill (Zawawi, Astimar, and Ridzuan 2015) and it is one of the major biomass waste produced in Malaysian palm oil industry. The Fresh Fruit Bunches (FFB) produced around 85.71 million tonnes in 2009, an estimated amount of 6.76 million tonnes of dried EFB was generated from oil palm mills (Izani et al., 2012; Sahari, Nuratiqah, & Rao, 2014). According to Aziz et al., (2002), every ton of fresh fruit bunch process, estimated 200kg of EFB are produce. The oil palm fibre that extracted from EFB is non-hazardous biodegradable material and the fibres are clean, non-carcinogenic and free from pesticides (Abdullah and Sulaiman 2013). Therefore, the use of OPEFB in cement boards production seen beneficial to humankind and environment through greener approach.

OPEFB is one of the lignocellulosic family fibre, where consists of three main components; hemicellulose about 19%-25%, cellulose 40% - 65% and lignin 19%-21% (Soom et al., 2006; Sreekala et al., 1997). Lignin, part of hemicellulose and sugar are well known as inhibitory substances for cement hydration when OPEFB incorporate in cement matrix (Na et al. 2014; Wei et al. 2002). Therefore, the utilization of OPEFB in cement boards production although beneficial in term of cost analysis, but the main obstacle for producing OPEFB-cement product is incompatibility between cement and OPEFB fibre.

There are several methods that commonly introduced to enhance the level of compatibility between natural fibre and cement. The most effective method that used by researchers are using natural fibre pre-treatment and introduce the cement-curing accelerator during the mixing process. Although, many research attempts has been made particularly to evaluate the OPEFB fibre pre-treatment using NaOH (Ariffin et al. 2008; Umikalsom et al. 1997; Zawawi et al. 2015) and incorporating OPEFB in cement composite (Abd. Aziz et al. 2014; Lertwattanaruk and Suntijitto 2015), but the research finding about relationship between OPEFB fibre pre-treatment and cement hydration is still vague and remain unsolved. Since the compatibility of OPEFB with cement needs to be evaluate before fabricating NFCC, thus reducing inhibitory substance in OPEFB is necessary to improve compatibility level OPEFB-cement composite.

The objective of this research is to evaluate the effect of OPEFB fibre pre-treatment using the different concentration of Sodium Hydroxide (NaOH) against surface morphology and hydration temperature when treated OPEFB mixed with cement.
2. MATERIALS AND METHODS.

2.1 EFB fibre pre-treatment and production methods

EFB fibre used for this research supplied by Kulim Plantation, Ladang Tereh Mill located at Kluang Johor. EFB fibre strand were soaked in Sodium Hydroxide (NaOH) at different concentration level for 24 hours. In order to gain better understanding on effect of EFB fibre pre-treatment on the change of surface morphology and compatibility when mixed with cement, NaOH concentration were set by two categories; low concentration at 0.2%, 0.4%, 0.6%, 0.8%, 1.0%, and high concentration at 2.0%, 4.0%, 6.0% and 8.0%. The EFB fibre strands then washed with tap water to remove any impurities and PH value measuring device is used to determine the PH value of wash water in order to ensure the presence of alkali from NaOH is removed. Then the treated EFB fibres were air-dried followed by oven dried at 100°C for 24-hours. Treated dried EFB fibre then hammer milled with size distribution about 9.5% retained 18 mesh, 23.8% retained 30 mesh, 51.3% retained 80 mesh, and 15.3 passing 80 mesh. The process of EFB fibre production was done at Timber Fabrication Laboratory, Faculty of Civil and Environmental Engineering, UTHM and Malaysian Palm Oil Boards Laboratory, UKM Research Centre Bangi Selangor.

2.2 Compatibility test

The compatibility test was done to investigate the effects of EFB fibre treated with NaOH with different concentration to the hydration rate of cement. This test is essential as it can determine the amount of NaOH, that can be used for EFB fibre treatment, the correlation between change of surface morphology and the rate of EFB fibre-cement hydration. Hydration test designed for this research were based on the method used by previous researchers (Ashori, et al. 2011; Hermawan, Subiyanto, and Kawai 2001; Noor Azrieda et al. 2009). The OPC type 1 cement were used in this study. 150 gram of cement mixed with 7.5 gram of fine EFB fibre, then the mixture added with 65.25mL of water. The mixture stirred for 2 minutes in polystyrene cup. Water used for this test was fixed at 0.4mL/g of cement weight plus 0.7mL/g of EFB fibre weight (oven dry basis). Control sample consists of cement (OPC type 1) and the mixture of untreated EFB fibre with cement. After the mixing, thermal couple (type T) was immediately inserted approximately at the center core of EFB fibre-cement mixture and connected to the data logger (Midi Logger Graphitec GL220). The mixture then placed in the thermos flask. This process was carried out for eleven samples. All the experiments were conducted in ambient room temperature and the data measured for 65 hours.

2.3 Surface morphology examination

The change of surface properties of EFB fibre due to NaOH treatment was examined using Scanning Electron Microscope (SEM). The SEM observation was conducted in the range of 200 to 500 magnifications as to obtain better view surface characteristic in order to gain deep understanding of the different effect at various concentration of NaOH. As found by Sreekala and Thomas (2003) and Zawawi et al. (2015), the used SEM image as 200 to 500 magnification is appropriate to make the conclusion through observation change of EFB fibre surface morphology due to variation treatment effect.
3. RESULT AND DISCUSSION

EFB fibre treatment in this study involved two stages (soaked in NaOH and hammer milled) in order to prepare lignocelluloses fibre. Introduction of NaOH as EFB fibre treatment medium as it is significantly contribute to the increment of cellulose and reduction in presence of hemicellulose and lignin (Ariffin et al. 2008; Umikalsom et al. 1997). In addition, NaOH act as swelling agent, thus able to penetrate the crystalline region resulted more hydrogen bonding were broken consequently more impurities and including oil were removed (M S Sreekala et al. 1997; Zawawi et al. 2015). While according to Kwei, Wan Rosli, and Arniza (2007), hammer mill process contribute to the surface characteristic change by reduce silica content of EFB fibre about 11.1% to 12.9%.

3.1 Surface morphology observation

Scanning electron microscope (SEM) image with various magnification ranges from 200 to 500 is used to observe the change of surface morphology of EFB fibre before and after pre-treatment. It is found that untreated fibre clearly showed (Figure 1a and 1b) the presence of silica bodies embedded in great number on EFB fibre strand. They attached to circular craters on the EFB fibre surface and spread relatively uniformly with the rounded spiky size of 10-14 μm. Zawawi et al. (2015) was obtained the similar result of existence of great number of silica bodies on EFB fibre strand while Kwei et al. (2007) found the presence of silica bodies on EFB fibre strand with rounded spiky size distribution 10-15 μm.

OPEFB treated with Sodium Hydroxide (NaOH) showed the reduction in presence of silica body (Figure 2(a) to Figure 2(i)). OPEFB treated with NaOH at 0.2% did not show much different in term of numbers of the presence of silica body. However after being treated with NaOH started 0.4% of concentration, some of the silica body started removed from the EFB strand and leaving the effect of crater-shaped holes. The increasing concentration of NaOH used, the lower number of silica body remained as obtained by (Ariffin et al. 2008; Sreekala, 1997; Zawawi et al. 2015) who found the reduction number of silica body on EFB fibre strand after being treated with NaOH. At 1% NaOH concentration (Figure 2e), it can be seen that the silica body almost completely dated from the EFB fibre strand. However, the dated silica bodies were not fully decomposed and the residue still remain on the fibre strand. When the NaOH concentrations reach at 2% (Figure 2f), the presence of silica body completely removed and
decomposed. Figure 2g showed that EFB fibre strand that treated with NaOH at 4% concentration. It is found that, the surface of EFB fibre strand turn more rough and uneven. Crater-shaped hole on EFB fibre strand started damage and deformed at 6% concentration of NaOH as shown in Figure 2h. Then, at the level of 8% NaOH, crater-shaped hole formed on the EFB strand surface completely disappear and leave the surface rougher and uneven (Figure 2i). According to Sreekala et al. (1997), the roughness surface of fibre strand due to alkali treatment could enhance the mechanical interlocking at the interface. However, to date, the comprehensive discussion related to the EFB fibre treatment and change of surface morphology to the cement setting very rare to find publish elsewhere.
Figure 2: Scanning Electron Microscope (SEM) image at 250 magnification of Oil Palm Empty Fruit Bunch (OPEFB) treated with Sodium Hydroxide (NaOH) range 0.2\% to 8\% concentration

3.2 Cement-EFB fibre hydration rate

The natural fibre to cement compatibility is still a major problem in cement bonded fibreboards production. Adding the certain amount of natural fibre into cement composite significantly reduce the hydration temperature of mixture. According to the results (Figure 3), it was found that, by using the 150g of OPC and 60mL water, the maximum hydration temperature obtain was 52°C at 10 hours. The hydration temperatures of neat cement totally depend on type of cement used, amount of cement and water used and sample size (Schackow et al. 2016). Through the research, when 7.5g fine untreated EFB fibre added, the hydration temperature increase at 30.5°C for first 2 hours and then gradually drop for remaining duration until reach the lowest temperature at 28°C. It shows that the EFB fibre cannot be used solely as cement fibreboards raw materials since it’s seriously inhibit exothermic chemical reaction between cement and water due to the inherent extractive in the fibre. However, the used of NaOH as treatment agent has changed the graph pattern where the mixture temperature increase depends on NaOH concentration. Through the research finding, the results can be categorized into three groups according to their temperature variation. First groups for that EFB fibre treated with NaOH at 0.2\% and 0.4\%. In this category, the maximum temperature obtained at 33°C and 34°C respectively at the time taken for both to reach peak temperature was 40 hours. The second group was the fibre treated with 0.6\%, 0.8\%, 1\% and 2\%. The range hydration temperature obtain from this group ranged from 35°C to 37°C at the time to hit the maximum temperature between 29 to 35 hours. The last group for the EFB fibre treated with 4\%, 6\% and 8\% of NaOH. The maximum temperature obtained from this group were 42°C to 44°C and the time taken to reach the maximum were between 11 to 15 hours. Overall, the temperature of cement-EFB fibre mixture increase with the increment of NaOH concentration used, infact the time taken to reach maximum temperature reduced simutaneously. Although the high NaOH concentration is used, the cement-EFB fibre mixture temperature still much different compared to neat cement.

3.3 Correlation of surface morphology and hydration temperature.

The silica body reduction from EFB fibre strand effect from NaOH treatment clearly shows a strong correlation to the increment of cement-EFB fibre hydration temperature as shown in Figure 2 and Figure 3. From the result, lesser silica body observed, higher hydration temperature of mixture. Removal of silica-bodies from fibre strand would enhance chemical penetration in pulping thus allow for hydrogen bonding removal from the fibre (Kwei et al. 2007; Sreekala et al.
Since NaOH acted as swelling agent during soaking process, it be able to penetrate the crystalline region and broken down more hydrogen bonding, resulted more impurities were removed (Sreekala and Thomas 2003). While Ibrahim et al. (2013) found that, the higher concentration of NaOH treatment apply distinctly reduced the amount of oil contain in the fibre. Therefore, it is essential to use treated EFB fibre before incorporated into cement composite due to incompatibility issues. However, higher concentration of NaOH used inappropriate for massive cement bonded fibreboards production.

Figure 3: Hydration temperature of OPC with treated and untreated EFB fibre

4. CONCLUSION

Based on the laboratory study, the following conclusion has been made;

(1) The use of NaOH as treatment agent significantly changes the surface morphology of EFB fibre strand. Higher NaOH concentrations apply, lesser silica body found on the EFB fibre surface. The silica body completely removed from the fibre strand started at 2% NaOH concentration.
(2) Treatment using NaOH successfully removed silica body that increased the cement-EBF fibre hydration temperature.
(3) The higher concentration of NaOH used, the EFB fibre surface become rough and uneven, thus allows NaOH penetration to crystalline region and resulted to removal of impurities in the fibre.
REFERENCE


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