Utilization of Industrial By-products as Cement Replacement Materials in Thailand

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ABSTRACT

In this work, a number of by-products available in Thailand were investigated for use as cement replacement materials. Particle size analyses were carried out using a scanning electron microscope and a laser particle size analyser. Measured particle size of these by-products was compared with those of Portland cement and also to the ASTM fineness requirement. The results showed that both fly ash and rice-husk ash had to be further processed through sieving and milling respectively in order to obtain the suitable particle size. Silica fume, on the other hand, was found to be extremely fine with its particle size being in the nano range (≈100nm). These by-products are also pozzolanic which can improve the properties of cement and concrete and therefore, has good potential for use as cement replacement materials in the Thai construction industry, provided its particle size is fine enough and meets the ASTM requirement.

Key words: Particle size, Cement, Fly ash, Rice-husk ash, Silica fume

INTRODUCTION

The use of industrial by-products as cement replacement materials started receiving a lot of attention in the late 20th century in Europe and America to cut down high energy required in the Portland cement manufacturing process (Malhotra and Mehta, 1996). Today, with the high price of petrol continues to increase, cutting back on energy use has become the nation's primary policy. However, in Thailand the primary cement being used for making concrete is still Portland cement. Although, there has been increasing use of fly ash (Mae Moh power plant technical information, 2001), other by-products are not recognized as widely. In this work, a number of by-products available in Thailand were investigated for use as cement replacement materials. These are rice-husk ash, silica fume as well as fly ash. This work looks into the potential of their uses in the Thai market in relation to their development in making them suitable for use as cement replacement materials. Test standards now recognize the mixture of such replacement materials and Portland cement as new cements, i.e., pozzolanic cements. Characterisations of the pozzolanic by-products were investigated, using various methods such as scanning electron microcopy (SEM) and laser particle analyser.

MATERIALS AND METHODS

Industrial by-products used in this investigation were rice-husk ash, silica fume and fly ash. Fly ash was collected from Mae Moh power plant in Lampang province while rice-husk ash was collected from a rice mill in Lampoon province and silica fume was obtained from a local construction material store. Powder characteristics such as the particle size, distribution

and morphology of these by-products were determined using standard sieves, a laser particle size analyser (CILAS 1064) and a Scanning Electron Microscope (SEM; JEOL JSM-840A). The standard sieve size used were 45 μm, 100 μm, 125 μm, 180 μm, 250 μm and 600 μm. The fineness of the particles was then compared to the requirement specified by the American Society for Testing and Materials (ASTM) C618: 2002. In order to meet the ASTM requirement, fly ash and rice-husk ash were further handled and treated. The former was sieved through a 100 μm aperture sieve while the latter was ball-milled at various periods up to 24 hours. Particle size of these by-products was again checked to ensure that it meets the fineness requirement of 34% maximum retention when sieved on a 45 μm (No. 325) sieve.

RESULTS AND DISCUSSION

From Figure 1, it can be seen that as-received fly ash particle size was smaller than 600 μm as the percentage passing at 600 μm aperture was found to be at 100%. It can also be seen that the cumulative percentage retained at 325 mesh sieve (45 μm) was found to be at ≈70 % which is coarser than that specified by ASTM standard. By studying the particle size of the fly ash, a suitable particle size distribution was selected using fly ash of 0–100 μm size or those having passed 100 μm aperture sieve size (150 mesh). The then measured cumulative retention at 45 μm sieve size was 34%, meeting the maximum requirement set by ASTM, thus this fly ash can be used as cement replacement. Furthermore, fly ash particles can be seen to be spherical in shape with a fairly smooth surface (Figure 2).

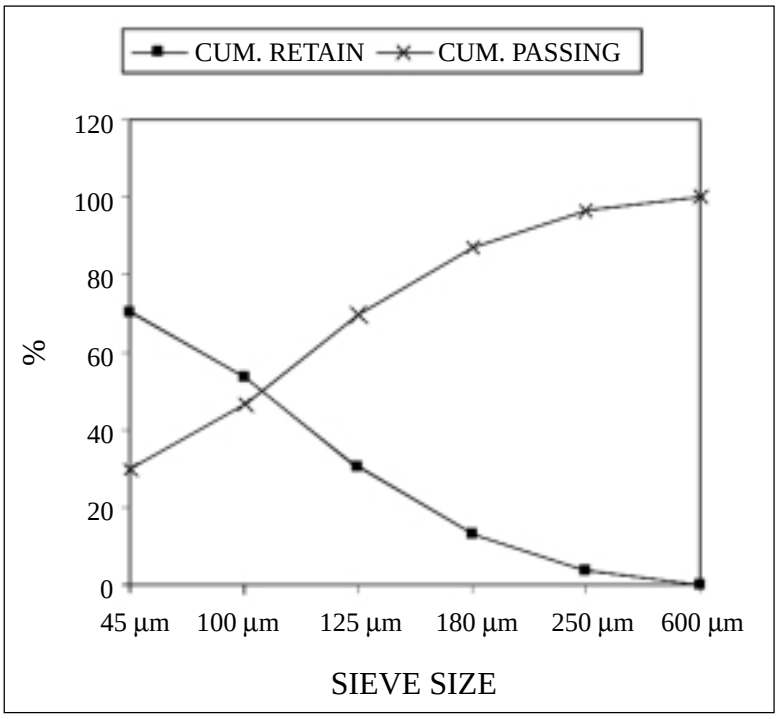

Figure 1. Particle size distribution of fly ash using standard test sieves.

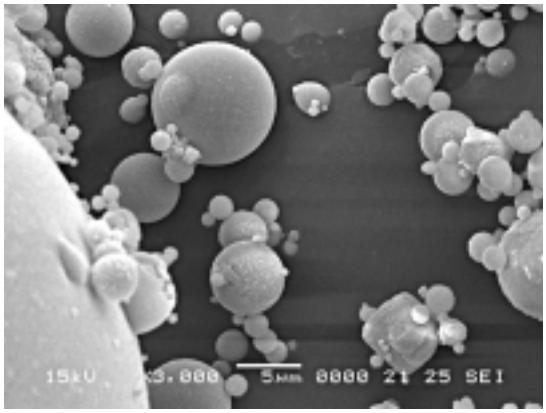

Figure 2. Scanning Electron Micrograph of fly ash.

Rice-husk ash, on the other hand, as-received particles were found to be coarse grains of husk having been burnt. When further ground by hand, the raw material was found to be very coarse as shown in Figure 3 (d50 = 51 μm). Rice husk was therefore ball-milled at 12 and 24 hours and its particle size and distribution was measured. The particle size at 50% cumulative passing was found to reduce to 6.81 μm and 4.87 μm when rice-husk ash was ball-milled for 12 hours and 24 hours respectively. The particle of rice-husk ash was found to be irregular in shape that appeared to be crusted together (Figure 4).

Figure 5 shows the scanning electron micrograph of silica fume. Silica fume can be seen to be rounded in shape and that typical particle size of silica fume was found to be ≈100nm, and thus that is very fine enough for use as cement replacement material.

From the above results, fly ash, rice-husk ash and silica fume can therefore be used as cement replacement materials, provided its particle size is fine enough and meets the ASTM requirement.

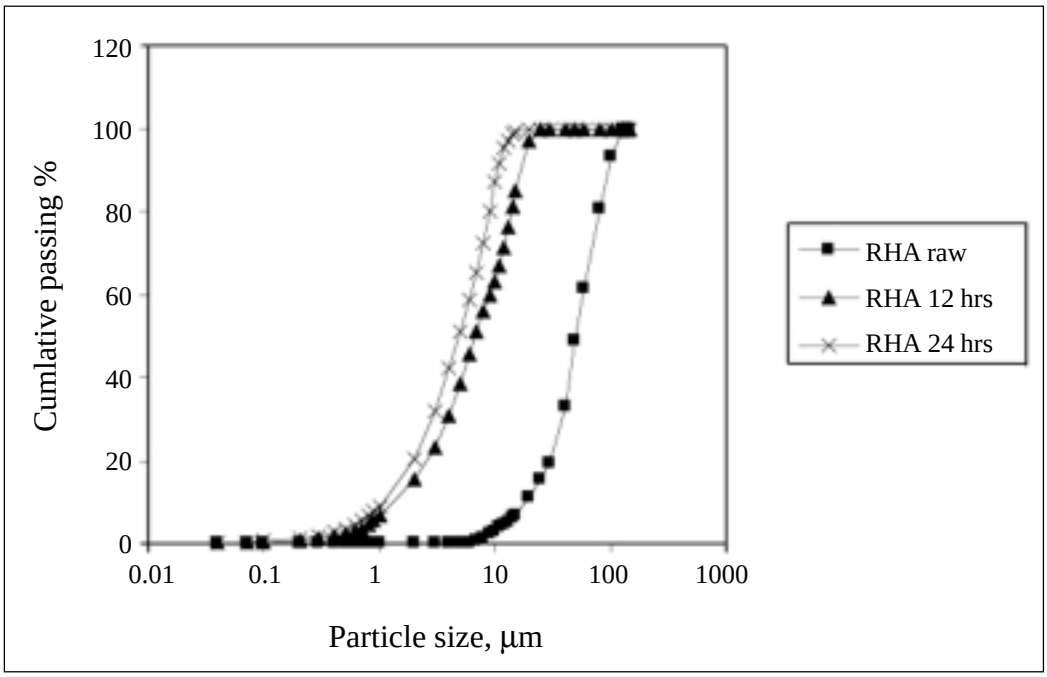

Figure 3. Particle size distribution of fly ash using a laser particle analyzer.

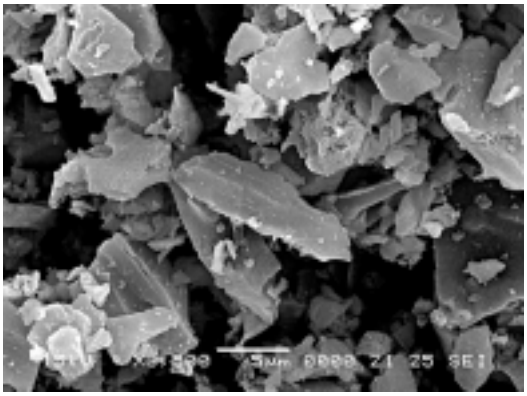

Figure 4. Scanning Electron Micrograph of rice-husk ash.

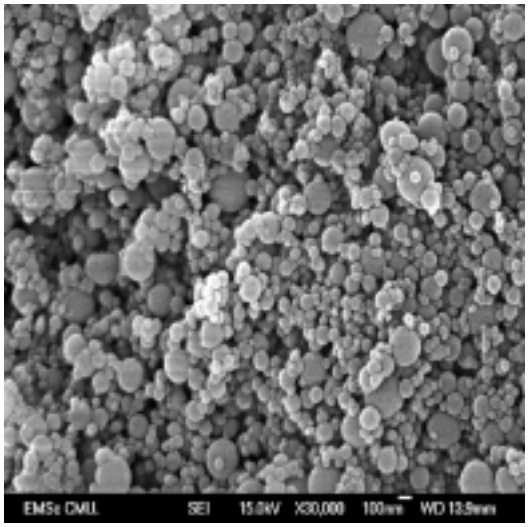

Figure 5. Scanning Electron Micrograph of silica fume.

CONCLUSION

The results showed that both fly ash and rice-husk ash had to be further processed through sieving and milling respectively in order to obtain the suitable particle size. Silica fume, on the other hand, was found to be extremely fine with its particle size being in the nano range (≈100nm). These by-products are also pozzolanic which can improve the properties of cement and concrete and therefore has good potential for use as cement replacement materials in the Thai construction industry, provided its particle size is fine enough and meets the ASTM requirement.

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The American Society for Testing and Materials (ASTM) C618: 2002.