CHAPTER 5

CONCLUSIONS AND SUGGESTIONS FOR FUTURE WORKS

The research was conducted to evaluate the potential utilization of MSWI fly ash as a cement replacement material in concrete applications. The effects of physical properties, chemical and mineralogical compositions on MSWI fly ash-cement mortar were carried out. To ensure safe utilization, the impact of MSWI fly ash product on environment was evaluated according to the leachate extraction procedure regulated in the Notification of Ministry of Industry No. 6 (1997). The following conclusions could be drawn from this study:

5.1 Characterization of MSWI Fly Ash

As-received MSWI fly ash obtained from Phuket incinerator plant was present mainly in large fractions with its mean particle size ($d_{50\%}$) of around 1000 microns. MSWI fly ash sifted through a standard sieve No. 200 (75-micron openings) was in the form of powder which had the particle dimensions between 30 and 80 microns. The MSWI fly ash particles were irregular and angular in shape with plenty of pores on rough surface. Investigation on chemical compositions of MSWI fly ash using X-ray analysis revealed large amounts of CaO, alkalines (Na_2O and K_2O), Cl, and SO_3. Besides high concentrations of these constitutes, low SiO_2, Al_2O_3, and Fe_2O_3 contents in MSWI fly ash made it unsuitable for pozzolanic material according to the ASTM C618 requirements. The study on mineralogical compositions presented numerous crystalline compounds of KCl (sylvite), NaCl (halite), $CaCO_3$ (calcite), $Ca(OH)_2$ (calcium hydroxide or portlandite), $CaSO_4$ (anhydrite), $CaCl_2$ (calcium chloride), and CaClOH (calcium chloride hydroxide).

5.2 Properties of Portland Cement with MSWI Fly Ash

In this section, mechanical properties of MSWI fly ash-cement mortars were studied. Investigation on normal consistency and setting time showed that MSWI fly ash-cement pastes required more water and curing time to obtain normal consistency and setting with the increase in percentage of MSWI fly ash replacement. The result also indicated that although the 28-day compressive strengths of all MSWI fly ash mortars were comparatively low, the compressive strengths of 10% and 15% MSWI fly ash mortars (90% of control) might be satisfactorily used in some applications. Low amounts of SiO_2 plus Al_2O_3 in MSWI fly ash may result in the lower compressive strength in mortars since both compounds contribute to high strength gain. Moreover, high content of CaO in the MSWI fly ash may retard the compressive strength development and cause unsoundness in MSWI fly ash mortar. However, incorporation of MSWI fly ash in concrete not only produce satisfactory result, but help to reduce the amount of incinerator residues so as to prolong precious service life of a landfill as well.

Major crystalline phases in MSWI fly ash-cement paste were $Ca(OH)_2$, C_3S, and C_2S. Investigation on the reduction of starting materials (C_3S) in cement paste and the increase of hydration products ($Ca(OH)_2$) showed that the intensities of C_3S were more rapidly consumed in the control paste than in the MSWI fly ash-cement pastes that were corresponding with the compressive strength development. However, the intensities of $Ca(OH)_2$ in MSWI fly ash-cement pastes were higher than in the control. The distinguished intensities of $Ca(OH)_2$ in MSWI fly ash paste may be a result of the nature of the ash that is associated with large amount of lime from flue gas treatment process more than the product of hydration process.

5.3 Leachate Characteristics of MSWI Fly Ash-Cement Products

Since the concentration of lead present in Phuket MSWI fly ash exceeded 20 times of the health-based heavy metal limits (Appendix VII, 40 CFR 266), It was required that TCLP be performed to determine lead and other heavy metals in the MSWI fly ash leachate. Even though the lead concentration did not pass 20 times of the limits, other regulated heavy metals in leachates of MSWI fly ash and the solidified MSWI fly ash products met the regulatory limits.

5.4 Suggestions for Future Works

1. Typical physical properties and chemical compositions of Phuket MSWI fly ash should be conducted to address seasonal variation of solid waste compositions.
2. Properties of MSWI fly ash should be enhanced in order to suit concrete applications such as washing with water or acid solution, grinding or classifying fly ash into several sizes.
3. Effect of MSWI fly ash incorporation in both fresh and hardened concrete should be investigated such as workability, permeability, durability, splitting tensile strength, flexural strength, resistance against acidic attack, and alkali-aggregate reactivity.
4. Long-term leaching test should be conducted on solidified MSWI fly ash products to ensure safe utilization.