CHAPTER 1

INTRODUCTION

1.1 General

Phuket's garbage problem immediately accelerated in the early 1980s with the growth of tourism in the region. As an international tourist destination, Phuket currently attracts around two million visitors each year. These tourists generate about 120 tons of solid waste each year. For the rapidly developing Phuket island, which has a land area of 570 km^2 and daily refuse output of about 230 tons (PC Monteney, 2001), disposal of municipal solid waste (MSW) has become a significantly economical and environmental challenge. A traditional waste disposal process of most MSW is landfill disposal. Due to the problem of landfill shortage and the closure of many existing landfills, incineration of MSW as a new alternative of volume reduction is widespread attention in many countries. Furthermore, incineration process can destroy harmful organic compounds, reduce the space required for landfill, and provide an attractive source of alternative energy. Even though MSW incinerator can reduce its volume by as much as 80%, it still leaves residues of ash and inert materials that require proper management.

Municipal solid waste incineration (MSWI) residues can be classified in two broad categories: bottom ash and fly ash. Bottom ash includes large and heavy particles removed from the bottom of combustion chamber. Conversely, fly ash includes very fine particles entrained in incinerator exhaust gases prior to discharging into atmosphere. The handling of both residues is mainly landfilled according to some regulation classifying these ashes as hazardous materials. Knowing that, they present a potential toxicity by reason of their heavy metals and salt contents as well as their chemical and leachable properties, MSWI residues can possibly post environmental impacts, though in landfill, if they are not handled appropriately. By means of protecting groundwater and soil from their leachate, such as lining the landfill, it may be expansive and is not an effective opportunity. These residues may require any treatment to reduce heavy metals and harmful organic compounds, thereby decreasing the potential migration of contaminants. Therefore, utilization of MSWI residues in construction applications would reduce the amount of ash in need for discarding, reduce some environmental problems, and conserve natural raw material for cement manufacture.

There are many state-of-the-art treatment processes for MSWI residues that could guarantee safe disposal or utilization including melting for metal treatment, destruction of dioxins, and volume reduction, cementitious S/S (stabilization and solidification) to reduce mobility of metals, stabilization with chemical agent, e.g. chelate and phosphate additive, and leaching with acids and other solvents (Cheng and Bishop, 1992; Buchholz and Landsberger, 1995; Rebeiz and Mielich, 1995; Ecke et al., 2000). Cementitious S/S has achieved the widest acceptance of fly ash treatment. This is probably a result of its low specific expense and also its easy operation. Compared to other technologies, cementitious S/S, however, involves the highest increase of solid waste mass, which can be up to 40% for cement additive and water.

MSWI bottom ash has been studied to utilize as a filling material in highway construction and embankment or as an ingredient in Portland cement concrete and concrete masonry (Rashid and Frantz, 1992; Berg and Neal, 1998). Like bottom ash, MSWI fly ash can be distinguished for engineering utilization into two groups, marine applications and civil engineering materials (Shieh, 2001). It can be substituted in cement to make concrete for shore protection and artificial reef units or used for road base, construction aggregate, asphalt pavement, masonry concrete block, and landfill daily cover. The most possible solution for fly ash management problem seems to be used in Portland cement concrete. However, the properties of fly ash concrete need to be studied in order to ensure that the new material is suitable for application.

Few studies have been conducted on utilization of MSWI fly ash as a cement replacement material in Portland cement concrete, as has been done with coal fly ash. Coal fly ash derived from power-generating plants has been successfully utilized in engineering applications; for instance, fly ash cement concrete, stabilized road bases, flowable fill applications, grouts for concrete pavement, and structural fills and embankments (Berry and Malhotra, 1987; Jaturapitakkul, 1993; Berry et al., 1994; Bilodeau et al., 1994; American Coal Ash Association, 1995; Lav, 2000). Because of its pozzolanic properties, coal fly ash can achieve more economical product, better workability, lower permeability, better strength properties, and better chemical resistance in fly ash-cement concrete. Moreover, coal fly ash has been used with field crops such as corn, soybean, and wheat as a soil conditioner and a topsoil substitute (Cline et al., 2000; Gorman et al., 2000). Conversely, there has been relatively little research on MSWI fly ash due to its heterogeneous and complex nature (Hamernik and Frantz, 1991a and 1991b; Triano and Frantz, 1992; Goh and Tay, 1993; Mangialardi et al., 1998; Rachakornkij, 2000).

1.2 Objectives

The main objective of the study is to investigate the characteristics of MSWI fly ash and properties of the fly ash as a partial cement replacement in mortar. The specific objectives are as follow:

1. To determine the physical and chemical characterizations of MSWI fly ash
2. To evaluate the utilization of the solidified MSWI fly ash-cement mortar for suitability in applications
3. To evaluate the potential environmental impact as a result of solidified fly ash products.

1.3 Scopes of the Study

The research was conducted to determine physical and chemical properties of MSWI fly ash and leachate characteristics of cement mortars incorporating MSWI fly ash. This MSWI fly ash was obtained from a mass-burn incinerator in Phuket, Thailand. The following works of the research were studied.

1. The characterization of MSWI fly ash sample under investigation included sieve analysis, particle size and specific surface, bulk specific gravity, moisture content and loss on ignition (LOI), pH and conductivity, morphology, chemical and mineralogical compositions.

2. The fly ash was mixed with Portland cement to make fly ash-cement products with 0%, 10%, 15%, and 25% fly ash replacement. In this experiment, a 1:1 replacement ratio by weight of fly ash added to weight of cement removed was prepared. Basic properties of Portland cement with the ash, such as normal consistency, setting time, and compressive strength were studied. To investigate the effects of fly ash on compressive strength and on the development of hydration and pozzolanic reactions, the fly ash products were tested at the ages of 1, 3, 7, 14, 28, 45, and 60 days.

3. The standard regulatory method to determine leaching metals involving an extraction test according to the Notification of Ministry of Industry No. 6, B.E. 2540 (1997) issued under Factory Act, B.E. 2539 (1996) was chosen to predict environmental impacts from the leachates of MSWI fly ash and the fly ash products.