CHAPTER 1 INTRODUCTION

1.1 Statement of Problem

In 2009, construction and demolition wastes (C&DW) generated in Europe, USA, and Japan had been reported to about 510, 317, and 77 million tons per year, respectively, but the waste recovered was 30, 82 and 80%, respectively (The Cement Sustainability Initiative, 2009). In Thailand, C&DW was about 10 million tons per year and all of it could not be recovered (The Cement Sustainability Initiative, 2009). If this waste could be recycled as an aggregate for use in concrete production, the amount of landfill required for disposal sites would be reduced, which would help to conserve natural resources.

In 2009, the total production of sugarcane in the world was estimated to be approximately 1,661 million tons. The largest producer of sugarcane is Brazil while Thailand is the fourth largest (Crop production, 2011). The total sugarcane production in Thailand was about 68.5 million tons (Office of cane and sugar board, 2010). Cordeiro, et al. (2004) suggested that the quantity of bagasse from the sugar production was approximately 26% of the sugarcane weight and the quantity of the bagasse ash from burning bagasse for producing electricity in the sugar industry was approximately 0.62% of the sugarcane weight which amounts to approximately 424,700 tons per year in Thailand.

Fluidized bed fly ash, a by-product from thermal power plants, has been produced approximately 400,000-500,000 tons each year in Thailand and little of it was used in concrete works due to large particles, irregular shape, and high porosity resulting in low workability, low compressive strength, and low durability of concrete. Most sources of fluidized bed fly ash are located closer to Bangkok. Thus, it is a better choice for the construction industry in Bangkok area if the fluidized bed fly ash is improved to have good pozzolanic properties.

The use of pozzolanic materials in concrete was found to be advantage by increase the compressive strength, reduce the total porosity and capillary pores, and increase the resistance of chloride penetration resulting in lower steel corrosion (Chindaprasirt, et al., 2005; Gonzalez-Fonteboa and Martinez-Abella, 2008; Chalee, et al., 2010). Pozzolans were also used in recycled aggregate concrete (Olorunsogo and Padayachee (2002); Ann et al. (2008); Tangchirapat, et al., 2008; Tangchirapat, et al., 2010). However, most previous researches have been focused on strength of recycled aggregate concrete (Ravindrarajah and Tam, 1985; Ravindrarajah, 1987; Buck, 1997). It is rarely found the researches reporting on the water permeability, chloride resistance, and expansion due to sulfate attack of recycled aggregate concretes containing pozzolanic materials such as ground fluidized bed fly ash and ground bagasse ash.

Recently, little amount of bagasse ash and fluidized bed fly ash have been used, thus the large amount of these ashes have been disposed to landfill as waste similar to the recycled aggregate. If the benefit of these ashes are studied and promoted for concrete production, the amount of required landfill for disposal sites will be reduced and can conserve natural resources. Therefore, this research aimed to use recycled coarse aggregate to fully replace natural coarse aggregate to produce recycled aggregate concrete and use ground fly ash and ground bagasse ash to partially replace cement to improve both mechanical properties and durability of recycled aggregate concrete. The

novelty of this research is the utilization of the waste ashes from power plants and waste concrete. Moreover, the results of this research are useful for concrete technologists to select a suitable replacement rate of ground fly ash, ground bagasse ash as well as recycled coarse aggregate to produce recycled aggregate concrete which has the suitable strength and good durability. The optimum amounts of fly ash and bagasse ash for making the preferable recycled aggregate concrete are indicated. The outcomes of this study would benefit to the reduction of cement usage, landfill, and natural coarse aggregate which are good for the environment and also reduces the cost of concrete.

1.2 Objectives

The objectives of this research are to study and develop fluidized bed fly ash, bagasse ash, and wastes of used concrete to be used as concrete materials. The objectives are drawn as follow:

1. To study the compressive strength and modulus of elasticity of recycled aggregate concrete containing ground fly ash and ground bagasse ash.

2. To study the water permeability, chloride penetration depth, and chloride content of recycled aggregate concrete containing ground fly ash and ground bagasse ash.

3. To study the expansion of recycled aggregate concrete containing ground fly ash and ground bagasse ash due to sodium and magnesium sulfate attacks.

4. To determine the suitable of ground fly ash and ground bagasse ash to replace Portland cement in recycled aggregate concrete mixture.

1.3 Scope of Study

This research investigated the strength, modulus of elasticity, water permeability, chloride penetration depth, chloride content, and expansion of recycled aggregate concrete. Water to binder ratios of concrete mix proportions were varied as 0.45, 0.55, and 0.65. Superplasticizer was employed in order to maintain the slump of fresh concrete between 50 and 100 mm.

Fly ash and bagasse ash were ground by ball mill until their particles retained on a 45 micron sieve (No. 325) were less than 1% by weight. Then, their physical properties and chemical compositions were investigated. After that, ground fly ash and ground bagasse ash were used to partially replace Portland cement type I at 20, 35, and 50% by weight of binder to cast concrete.

Recycled coarse aggregate in this study was obtained from crushing 150x300 mm concrete cylinder samples after the concretes were tested for compressive strength (25-40 MPa) by a swing hammer crusher. These concrete cylinders were sent by construction companies in Thailand to the Department of Civil Engineering, King Mongkut's University of Technology Thonburi to determine the compressive strength. The maximum size of recycled coarse aggregate is 19 mm and its particle size distribution is compared to the size required by ASTM C 33 (2001).

The compressive strengths of concretes with 100 mm in diameter and 200 mm in height were determined at the ages of 7, 28, 60, 90, and 180 days. The moduli of elasticity of concretes were determined at the ages of 28, 60, and 90 days. The water permeability

coefficients of concretes were determined at the ages of 28 and 90 days. The chloride penetration depth and chloride content of concretes immersed in 3% concentration of sodium chloride solution were measured. In addition, the expansions of concretes with water to binder ratio of 0.65 immersed in 5% concentration of sodium sulfate and magnesium sulfate solutions were also investigated.

1.4 Dissertation Outlines

This dissertation composed of five chapters and seven appendices. The first chapter illustrated the problem statements, objectives, scope of study, and dissertation outlines. In chapter 2, the literature reviews on the properties of fluidized bed fly ash, bagasse ash, recycled aggregate, and recycled aggregate concrete were presented. Moreover, the properties of recycled aggregate concrete such as fresh concrete, setting time, compressive strength, modulus of elasticity, water permeability, chloride resistance, and expansion of concrete were reviewed. Chapter 3, materials and experimental program including materials and test programs were presented. In chapter 4, material properties, namely physical and chemical properties of materials were reported and discussed. In addition, fresh, hardened, and durability properties of recycled aggregate concretes were reported and discussed. Conclusions and future works were summarized in Chapter 5. Finally, references and appendices were provided at the end of this dissertation.