CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Concrete is the most widely used man-made construction material, obtained by mixing cement, water, aggregates and admixtures, which offers stability and flexibility in designing all building structures. There are many advantages of using concrete such as easy to construct, fire resisting, has high compressive strength and requires low maintenance. Unfortunately, concrete is not environmentally friendly materials, either to make, or to use, or to dispose of, or even it can be recycle. At the same time, concrete also has a disadvantage which is low strength in flexural and brittle materials and therefore reinforcement bars have been introduced to solve this weakness. However, the corrosion of reinforcement bars is one of the major problems with concrete structure and it is inevitable during its life span that can lead to structural integrity. It can be caused by internal and external factors such as being attacked by chloride ions from the environment and chloride from materials to produce concrete. Concrete with high porosity and permeability is also susceptible of harmful substances that easily penetrate and cause the corrosion of reinforcement bars.

Theoretically, bars embedded in concrete structures are protected both chemically and physically against environmental corrosion by the concrete cover. The high alkalinity of the pore solution ranging from pH 12.5 to 13.5 of the concrete cover provides a chemical protection by the formation of a protective oxide film or passive layer on the surface of the bars. The impermeability of the concrete cover is expected to provide a physical protection against the ingress of deleterious materials like chloride ions that are known to cause a breakdown of this passive layer when the [Cl\textsubscript{2}]/[OH\textsubscript{2}]
ratio at the surface of the bars reaches a threshold value of 0.3 (Diamond, 1986). The diffusivity of chloride through concrete therefore depends on the microstructure of the concrete cover.

The use of fly ash as a cement replacement material has become a common practice in the recent years. Fly ash is used in concrete for several economic and environmental reasons. Moreover, the fly ash particles react with calcium hydroxide, producing hydration products that strongly decrease concrete porosity and permeability by producing a dense microstructure (Kawamura and Torii, 1989) which is an improvement in the physical protection of any embedded bars. In addition to this, if there is chloride binding by the aluminate phase of the fly ash to form Friedel’s salt, then the concentration of the free chloride ions in the pore water of concrete would be expected to decrease.

The growing Malaysian population along with the rapid development of the country has boosted the growth of the construction industry to meet the demands of end users. This scenario would lead to the consumption of more cementitious materials to be used in concrete productions. The rising cost of cement productions and environmental issues have resulted in the cement manufacturers and parties involvements in concrete production to find a solution that could allow the sustainability of concrete productions. It will provide an opportunity to researchers to explore and produce new materials in concrete productions. Therefore, by utilizing the previous research findings in the utilization of by-product materials, this study has developed a new cementitious material that can be used and improves concrete properties particularly in its strength and durability.

1.2 AIMS AND OBJECTIVES

The aim of this study is to develop concrete with high resistance towards chloride ions that could protect steel reinforcements from corrosion by using by-product materials namely palm oil fuel ash (POFA) and pulverized fuel ash (PFA). The specific objectives of the present study are as follows:
i. To determine the effects of POFA and PFA as a cement replacement on concrete compressive strength development.

ii. To determine the effects of POFA and PFA as a cement replacement on concrete porosity.

iii. To evaluate the performance of POFA and PFA as a cement replacement material towards chloride ion resistance of concrete and reinforcement corrosion.

iv. To determine the effects of POFA and PFA towards concrete hydration products namely C–S–H gel and Ca(OH)₂ which contribute to the concrete corrosion resistivity.

v. To find an optimal mix proportion of POFA and PFA as a cement replacement in concrete to resist the reinforcement corrosion without compromising the compressive strength.

1.3 PROBLEM STATEMENT

The common problem faced by reinforced concrete structures is the corrosion of steel reinforcements inside the concrete as time goes by and attacked by external corrosion agents. The severe tropical environment will accelerate the corrosion process that would lead to a shorter lifetime of a reinforced concrete structure. There are numerous examples of ‘spalling concrete’ found on reinforced concrete structures within marine and urban environments. Many concrete structures which have been exposed to aggressive environments, suffer from durability problems and fail to fulfill their design service life requirements. The problem is particularly serious in reinforced concrete structures where corrosion of the reinforcing steel can impair their safety and integrity. In a reinforced concrete structure, chloride ion penetration can be considered as a major cause of the corrosion of the reinforcing bars. Chlorides can penetrate through the concrete to reach the reinforcement bars and break down the passive oxide layer of the reinforcement bars to initiate corrosion. Due to this reason, concrete with