CHAPTER 1: INTRODUCTION

1.1 Background

In the modern world, concrete is the second largest consumable material after water. From material process, mixing and proportioning, delivery, placement and finishing sustainability of concrete is regarded as an ‘eco-green’ material. It is a matter of fact that the sustainability and ecological balance in the concrete production is more important than the unit price of concrete. The concrete industry of tomorrow will have to continue to produce a commodity product and also niche concretes with high added value (V.M. Malhotra and K.P. Mehta, 2004).

Among all the materials used in making concrete, cement production emits the highest amount of carbon dioxide (CO_2) gas into the environment. Cement contributes about 15% weight in the total production of nearly 5 billion ton/year.

In 2004, global CO_2 emissions from cement production were reported as 298 million metric tons which is 3.8% of the global CO_2 emission. The amounts of CO_2 embodied in concrete are primarily a function of the cement content in the mix designs. It is important to note that structures are built with concrete and not with cement. A portion of the CO_2 produced during manufacturing of cement is reabsorbed into concrete during the product life-cycle through a process called carbonation. Study estimates that between 33% and 57% of the CO_2 emitted from calcinations will be reabsorbed through carbonation of concrete surfaces over a 100 year life cycle. In 2005, China and India tops the cement manufacturing market followed by the US producing as total of 2300 million tons of cement annually (G.N. Edward *et.al*, 2003)

In view of the need for optimum use of cement in concrete; since last two decades, huge efforts were made to enhance the performance of concrete that involves better compaction, enhanced paste characteristics, and perfect bond between aggregate-matrix and reduced porosity. In these systems, a substantial reduction in water-to-cement ratio is achieved through the use of super-plasticizers; further enhancements of some properties have been obtained through the addition of mineral micro-fillers (supplementary cementitious or pozzolanic materials such as silica fume and fly-ash) and recycled concrete wastes from construction structures demolitions (M.D. Luther and P.A. Smith, 1991; Federal Highway Association, 2008; V.M. Malhotra and K.P. Mehta, 2004)

High Performance Concrete (HPC) is a specialized series of concrete that is designed to provide several benefits in the construction of structures that cannot always be achieved routinely using the conventional ingredients, normal mixing and curing practices. In simple manner, HPC is produced where certain characteristics are developed for a particular application and environment so that it can give excellent performance in the structure in which it is to be placed, the environment in which it is to be exposed and with the loads that is supposed to be encountered during its design life. An example of a characteristic that may be considered critical in an application requiring performance is the early age strength. Concretes possessing this characteristic often achieve higher strength. Therefore, HPC is often of high strength, but high strength concrete may not necessarily be the high performance. Traditionally, interests in the strength of concrete have been focused on those at the age of 28 days and beyond (M.L. Gambhir, 2005; A.M. Neville, 1998 and M. Ali, 1996).

Besides having huge favor in the urban mainland constructions, the marine environment is also given great attention. In tropical countries such as Malaysia, the chloride content in sea waters is said to be drastically increasing annually by 3% due to increased temperature and salinity concentrations. This phenomenon mainly happens at concrete jetty structures and platforms. To what is known, reinforced concrete is usually durable and cost effective which causes the widespread use for the construction of concrete structures. However, it has become increasingly apparent that the attack by aggressive agents such as chloride ions, leading to corrosion of embedded steel, causes a structure to deteriorate. Thus, the corrosion of reinforcing steel in concrete due to chloride transport in concrete structures in a marine environment has received increasing attention in recent years because of its widespread occurrence and the high cost of repair. Thus, it is important to know how much can this ion penetrate HPC and how durable HPC is to this aggressive chemical. This can be done by measuring the depth penetration of salt water in samples. To prevent chloride permeation into concrete, finely grained materials are used where it has been investigated and proven to be successful (K. Chong and R. Larrard, 1996).

Currently it is a major concern to achieve sustainable construction. Building and structures enabled mankind to meet their social needs for shelter, economically for investment and to achieve corporate objectives. However, the satisfaction of these needs usually comes with high price for example an irreversible damage to our environment. This leads to a growing realization around the world to alter or to improve our conventional way of development into a more responsible approach which can satisfy our needs for development without harming the world that we are living in. An opportunity sparked when a new philosophy called 'sustainable development' was introduced in 1987 in the Bruntland Report. Since then, many progressive world events had taken place to increase the awareness on environment and sustainability agendas such as Rio Earth Summit 1992, Maastricht Treaty 1992, Kyoto Protocol on Global Warming 1997, Johannesburg Earth Summit 2002 and Washington Earth Observation Summit 2003. Through sustainable construction concept, the construction industry can contribute in a positive way and proactive manner towards environmental protection (M.F.M. Zain *et.al,* 2005).

Delivering sustainable construction requires action from all engaged from constructing to maintaining the structure or building. This includes providing design, consulting and construction services (W. Atkins, 2001). It requires exploration to new territories in construction approach and prepares to adopt new products, ideas and practices. As global interest on sustainability starts to bloom, Malaysia should not be left out in triumphing on sustainability and sustainable construction. Malaysia needs to express herself so to abide by this new interest to compete in the global market (G. Ofori *et.al*, 2000).

In Malaysia, to achieve sustainability in construction. Construction industry must inevitably change its historic methods of operating with little regard for environmental impacts to a new mode that makes environmental concerns a centerpiece of its efforts. Previously, the concern on environment is relatively a small part of most of construction development. However with the growing awareness on environmental protection due to the depletion of natural resources, global warming and extremity of destruction to ecology and biodiversity impact, these issues have gain wider attention by practicing engineers worldwide. The direction of the construction industry is now shifting from developing with environmental concern as a small part of the process being integrated within the wider context of environment agenda. Thus, the activities of construction industry must work and comply with the needs to protect and sustain the environment.

Sustainable construction, which has been dubbed ‘green construction’, describes the responsibility of the industry in attaining sustainability. The term sustainability has been adopted as a panacea for change and development (C. Hayles, 2004)

1.2 Problem Statement.

One of the most serious problems in the production of huge quantity of concrete is the large amount of CO_2 emission and energy consumption during concrete production. About 7% of CO_2, is generated worldwide through concrete production. Resource productivity considerations will require minimizing Portland cement use to meet the future demands of eco-friendly concretes. Since the demand for higher concrete strength are increasing rapidly, consumption of cement in the construction industry has increased about 600-700 kg/m^3 annually. The depletion of resources as basic raw materials may worsen the condition with the reduction of lime stone deposits. Thus in order to optimize the cement content that is needed most appropriately, which is required to investigate the efficiency of cement through detailed research.

- To produce ecological friendly, cost effective and cement efficient concrete product to overcome the environmental issue of increasing carbon dioxide (CO_2) emission in the atmosphere and depletion of major resources.

- Deterioration of reinforcing bars embedded in concrete through corrosion

- To align with the policy of sustainable development and the application of GREEN Technology in the Concrete Industry.

1.3 Objectives.

The principle objective of this research was to investigate series mixes that utilizes the optimum cement content and achieve high early strength. The targeted 28 days strength was 50-80 MPa. In order to achieve the main objectives, the following sub-objectives were designed:

- To determine the effects of aggregate grading on the efficiency of cement in concrete from 'Designed' and 'As-supplied' graded aggregate mixes. The high early compressive strength development is to be considered.

- To assess the durability performance of the series mixes through estimation of potential durability. The potential durability was estimated from the effects of aggregate grading and measured values of porosity, splitting tensile strength, chloride penetration and the Modulus of Elasticity (E-Modulus).

- To determine the relationship of cement consumption, energy efficiency in concrete production and economic efficiency of concrete materials. The amount of CO_2 emissions to measure how 'eco-green' the concrete materials with comparison with other research.

1.4 Scope of Works

For this research, the boundaries and the scope of works covers as stated below:

- The development of concrete material strength of 28 days and beyond. The high early strength development of day 3 and day 7 were also taken into consideration.

- The measurement of durability performance of concrete material to cater to ease concerns of researchers in the construction industry.

- The effects of aggregate grading without making OPC as the main contributor to achieve high strength in concrete materials.

- To reduce environmental impact by reducing OPC consumption and producing worksheets to ease designers in their calculations. The impact of the CO_2 emission was determined.