CHAPTER 1

INTRODUCTION

1.1 History of Geopolymer

The threat of climate change is considered to be one of the major environmental challenges for the society. The production of cement contributes to the emission of CO_2 through the decarbonization of limestone. Cement is one of the most important building materials used worldwide for the production of concrete. The cement industry is a major source of carbon emissions and deserves attention in the assessment of carbon emission-reduction options. It is responsible for about 6% of all CO_2 emissions, because the production of one ton of Portland cement emits approximately one ton of CO_2 into the atmosphere (Davidovits, 1994c and Mc Caffrey, 2002).The contribution of Ordinary Portland Cement (OPC) production worldwide to greenhouse gas emissions is estimated to be approximately 1.35 billion tons annually or approximately 7% of the total green house gas emission to the earth's atmosphere (Malhotra, 2002).

Concrete is the most commonly used construction material in the world due to its high compressive strength, durability and availability. One of the efforts to produce more environment friendly concrete is to partially replace the amount of OPC in concrete with by-product materials such as fly ash. Fly ash is a residue from the combustion of coal which is widely available worldwide and leads to waste disposal proposal problems. Recent research has shown that it is possible to use 100% of fly ash as the binder in mortar by activating it with an alkali component, such as silicate salts and non silicate salts of weak acids (Bakharev et al (1999a), Talling et al (1989)). In fly ash based geopolymer concrete the silica and the alumina present in the source

materials are first induced by alkaline activators to form a gel known as aluminosilicate. This gel binds the loose aggregates materials in the mixture to form the geopolymer concrete (Wallah, 2010). This inorganic aluminosilicate polymer is called geopolymer.

In 1978, Davidovits (1999) proposed that binders could be produced by a polymeric reaction of alkaline liquids with the silicon and the aluminium in source materials of geological origin or by-product materials such as fly ash. He termed these binders as geopolymers. Two main constituents of geopolymers are source materials and alkaline liquids. The source materials of alumino-silicate should be rich in silicon (Si) and aluminium (Al).

This research work covers an extensive study on fly ash based geopolymer concrete block which aims at a 100% replacement of cement with fly ash as an alternative binding material. The first part of the research studies the manufacture of low calcium fly ash based geopolymer concrete and properties such as compressive strength, split tensile strength, flexural strength. Geopolymer concrete specimens are also tested for chemical resistance. Property study is performed by casting geopolymer concrete block and hollow blocks. Behaviour of unreinforced geopolymer concrete brick prism is also studied.

1.2 Problem Statement

The world is facing the challenge of global warming and climate changes due to carbon dioxide (CO_2) greenhouse gases and increment of CO_2 concentration. According to current trends and development the industrial sector has a big challenge to maintain high quality of life while ensuring low energy consumptions and CO_2 emissions. Sustainable development of technologies for the industrial waste utilisation to building construction areas

is given considerable worldwide attention due to their advantages of green house gases reduction from Portland cement production and applications in waste management. Introducing Geopolymer Materials not only for environmental issue but also for reduction of carbon dioxide emission caused by 80% to 90% of Ordinary Portland Cement (OPC) in building construction. Due to the absence of cement in geopolymer mixtures many researchers believe that the geopolymer concrete will be the future concrete.

1.3 Low Calcium Fly Ash Based Geopolymer Concrete

In this research work, low calcium fly ash based geopolymer concrete is obtained from Ennore Power Station, Tamil Nadu, India was used as the base material. Geopolymer concrete is the name given to concrete where the binder is entirely replaced by an inorganic polymer formed between a strong alkaline solution and an aluminosilicate source. The source material such as fly ash, that is rich in silicon (Si) and aluminium (Al) are activated by alkaline liquid to produce the binder. The fly ash-based geopolymer paste binds the loose coarse aggregates, fine aggregates and other un-reacted materials with alkaline liquid that is a combination of sodium silicate and sodium hydroxide solutions to form the geopolymer paste that binds the aggregates and other non-reacted materials together to form the geopolymer concrete.

1.4 Research Significance

The study on the properties of geopolymer concrete is of supreme importance for instilling confidence in engineers and builders. The literature indicates that some studies are available on geopolymer concrete using fly ash and other materials as a substitute for cement. The utilisation of fly ash in geopolymer concrete could turn this waste material into a valuable resource with the added benefit of preserving environment. This research is conducted

to evaluate the potential use of fly ash to reduce the addition of cement in the production of high performance concrete.

1.5 Motivation for Research

Fly ash is one of the materials used in geopolymer concrete that could be considered otherwise as a waste material with a promising future in the construction industry as a partial or a full substitute of cement. Geopolymer concrete shows significant potential to be a material for the future because it is not only environment friendly but also possesses excellent mechanical properties. Practical recommendations on the use of geopolymer concrete technology such as precast concrete products and waste encapsulation needs to be developed in Indian context. Due to lower CO_2 emission contents of ingredients of geopolymer based composites compared to those of conventional portland cement concretes, the new composites can be considered to be more eco-friendly and hence their utility in practical applications needs to be developed and encouraged. Eventually the study results will be a foundation to commercialize the concrete mixture and will be a boon to concrete manufacturing sector. This was the main motivation for the present research study.

1.6 Objective of the Research

The main objective of the research is to conduct an extensive study on geopolymer concrete block.

The sub objective includes the following:

1. To study the physical, mechanical and chemical property of geopolymer concrete block.

2. To study the Mechanical property of geopolymer concrete hollow block.

3. To study the behavior of unreinforced geopolymer brick masonry prism of varying height.

1.7 Organisation of the Thesis

The thesis is organized into six chapters. **Chapter One** describes the motivation for developing fly ash based geopolymer as an alternative binder for concrete. **Chapter Two** reviews the literature on the utilisation of fly ash, geopolymer technology and the type of raw materials suitable for alkali activated binder and the factors affecting the durability properties of concrete. **Chapter Three** reports on the materials used for making geopolymer concrete in this experimental investigation. **Chapter Four** deals with the experimental studies including with testing procedures used for the evaluation of different concrete properties of geopolymer concrete block and hollow blocks. Tests were also performed to study the behaviour of unreinforced geopolymer brick masonry prism of varying height. In **Chapter Five** the test result from chapter four are analysed and discussed. Regression equation and chi square test are presented at the end of the chapter. **Chapter Six** states the summary and the conclusions of the study followed by a set of recommendations for future work.