CHAPTER 1

INTRODUCTION

1.1 GENERAL

Concrete, the predominantly used construction material in the world has gained its popularity because of its multiple benefits like relatively low cost of production, ease of handling, capacity to be moulded into desired shape, achievement of desired strength ranging from low to very high, serviceability and durability. The principal ingredient of concrete is cement, generally Ordinary Portland Cement (OPC) which acts as the binder and holds the aggregates intact. But unfortunately, OPC is found to be associated with some adverse effects on environment. The production of OPC is highly energy intensive and emits high amount of CO$_2$ into the atmosphere which contributes significantly to the ‘Green House’ effect. Bhanumathidas & Mehta (2001) stated that the production of one tonne of cement consumes nearly about 1.5 tonnes of earth minerals and also one tonne of CO$_2$ is released into the atmosphere. The raw materials required for cement production are non-renewable and are depleting at a rapid rate. But at the same time, a number of industrial and agro wastes with inherent cementitious properties are produced abundantly. But they are mostly disposed into landfills. Employing such by-products as alternates for cement has various benefits including conservation of environment, sustainability of resources and solving the disposal problem of by-products. Particularly in India, with the ever growing demand for cement to cater the rapidly developing constructions and infrastructure projects, the
impact created by OPC on the environment is massive. Hence, there is an immediate necessity to control the usage of OPC by developing potential alternates for it. In that context, extensive researches are being carried out around the world in analysing the possibilities of using substitute materials for OPC concrete. One such alternative is ‘geopolymer concrete’ (GPC) which completely eliminates OPC in its production.

1.2 GEOPOLYMER CONCRETE

In 1978, Joseph Davidovits (1999) proposed that it is possible to produce binders resulting from the polymerization reaction between alkaline liquids and source materials that are rich in silica and aluminium. He coined the term ‘geo-polymer’ to describe this family of mineral binders that possess a chemical composition similar to zeolites but exhibiting an amorphous microstructure. Paloma et al (1999) suggested that pozzolanic materials like blast furnace slag can be activated with the help of alkaline liquids to produce binders which could completely replace OPC in concrete production. Contrasting to OPC concrete (OPCC), the principal binders in GPC are not calcium-silicate-hydrates (C-S-H). Instead, an alumino-silicate polymeric gel formed by tetrahedrally-bonded silicon and aluminium with oxygen atoms shared in between acts the binder. The two important constituents of GPC are source materials and alkaline liquids. The source materials must be rich in silicon (Si) and aluminium (Al). These could be of geological origin like metakaolin or by-product materials like fly ash, Ground Granulated Blast furnace Slag (GGBS), silica fume, rice-husk ash, etc. The alkaline liquids are based from soluble alkali metals usually being sodium or potassium. The most common alkaline liquid used is a combination of sodium or potassium hydroxide along with sodium or potassium silicate correspondingly.
1.3 **SIGNIFICANCE OF THE STUDY**

Black Rice Husk Ash (BRHA) is an agro-industrial waste generated from rice milling industry. It is obtained by incinerating the rice husk. The resultant ash from this combustion process has a high content of unburnt carbon. Consequently, the use of BRHA as a construction material is very limited, even though it has high silica content about 90%. Although, several researchers including (Chatweera & Lertwattanaruk 2011; Piyaphanuwat & Asavapisit 2009) have reported that the addition of BRHA in concrete has improved its durability property. In GPC, most of the research works have been made on fly ash based geopolymers and occasionally on GGBS based geopolymers. As per the author’s knowledge, no published works are available related to the use of BRHA in geopolymer concrete. In this present study, industrial waste which is Ground Granulated Blast furnace Slag (GGBS) and agro waste which is Black Rice Husk Ash (BRHA) were used as source materials to produce geopolymer concrete. GGBS was kept as the base material in which BRHA was added in different percentages. The geopolymer concrete specimens were subjected to a range of test methods to ascertain their performance in different strength and durability conditions. The results of this investigation may provide useful data on the strength and durability of geopolymer concrete that has been developed from GGBS and BRHA, which are essentially industrial by-products. Such tested scientific information on geopolymer concrete will help in changing the perception of conventional concrete and also a broader recognition of this material in practical applications.

1.4 **OBJECTIVES OF THE STUDY**

Geopolymer concrete not only proves to be an efficient substitute to OPC concrete but also alleviates the disposal problem associated with
industrial by-products like GGBS and BRHA, by making use of them as chief ingredients for concrete which are generally getting dumped as wastes otherwise. The other specific objectives of the study are as follows:

- To develop geopolymer concrete mixtures using GGBS and BRHA.

- To study the influence of salient parameters on the compressive strength of the geopolymer concrete which include curing temperature and concentration of sodium hydroxide used for the alkaline solution.

- To study the performance of the geopolymer concrete under different durability criterion like sorptivity, chloride penetration, accelerated corrosion, acid and sea water resistance.

- To identify a suitable mix proportion for the geopolymer concrete in terms of percentage of GGBS, BRHA and also on the optimum curing temperature and concentration of sodium hydroxide used as the alkaline solution.

- To compare the manufacturing costs of geopolymer concrete with conventional concrete.

1.5 SCOPE OF THE STUDY

In this investigation, GGBS was utilized as the base material for making the control geopolymer concrete. Then BRHA was used to replace GGBS in the mix in three different proportions, for the rest of the mixes used in the study.

Basic strength parameters including compressive strength, tensile and flexural strengths of geopolymer concrete were studied. Besides, the
influence of curing temperature and the concentration of sodium hydroxide used in the alkaline solution on the compressive strength of geopolymer concrete were studied. To justify the title of the thesis, the investigation mainly focussed on the performance of geopolymer concrete made with GGBS and BRHA pertaining to different durability conditions including sorptivity, chloride resistance, resistance to accelerated corrosion, resistance to attack of acids and resistance to sea water.

1.6 ORGANIZATION OF THE THESIS

This thesis is divided into five chapters. The introductory chapter contains information on the background of this research related to the problems associated with OPC, the need for developing alternatives, geopolymer concrete, its origin, composition, advantages and also the significance, objectives and scope of this research work. Chapter 2 contains the literature review of the research work. Previous research works related to the current topic of research are discussed. Chapter 3 contains the methodology of the experimental programs, mix proportions, materials and their properties, laboratory tests and the mechanisms used to assess the strength and durability properties. Chapter 4 contains the discussion and analysis of all the results obtained from the experimental program. Chapter 5 contains the analysis of interrelationship between strength and some durability factors. Chapter 6 gives the summary and conclusion derived from the analysis of results and also gives some recommendations for future work in this topic of research.