CHAPTER - 1

INTRODUCTION

1.1 GENERAL

The production of Portland cement worldwide is increasing 9% annually. Portland cement (PC) production is under critical review due to high amount of carbon dioxide gas released to the atmosphere and Portland cement is also one among the most energy-intensive construction material. The current contribution of greenhouse gas emission from Portland cement production is about 1.5 billion tons annually or about 7% of the total greenhouse gas emissions to the earth's atmosphere. Geo-polymer concrete is a 'new' material that does not need the presence of Portland cement as a binder. Instead, the source of materials such as fly ash (FA) and ground granulated blast furnace slag (GGBS), that are rich in Silicon(Si) and Aluminum(Al),are activated by alkaline liquids to produce the geo-polymeric binder.

The major problem the world is facing today is the environmental pollution. But the production of cement means the production of pollution because of the emission of CO_2 during its production. There are two different sources of CO_2 during cement production. Combustion of fossil fuels to operate the rotary kiln is the largest source and other one is the chemical process of calcining limestone into lime in the cement kiln. **Hendriks et al**., carried out studies on emission reduction of green house gases from the cement industry. **Ernest Worerell** and **Lynn Price etal**, have reported about CO_2 emission from the global cement industry. In India about 2,069,738 thousand metric tons of CO_2 was emitted in the year 2010. And also, the cement is manufactured by using the raw materials such as lime stone, clay and other minerals. Quarrying of these raw materials also causes environmental degradation. To produce 1 tons of cement, about 1.6 tons of raw materials are required and the time taken to form the lime stone is much longer than the rate at which humans use it.

On the other side the demand of concrete is increasing day by day for its ease of preparing and fabricating in all sorts of convenient shapes. So to overcome this problem, the concrete to be used should be environmental friendly. To produce environmental friendly concrete, it is necessary to replace the cement with the industrial by products such as fly ash

(FA), GGBS etc,. GGBS is a by-product from the blast-furnaces used to make iron. The molten slag is rapidly chilled by quenching in water to form the sand like granulated material. GGBS is a glassy granular non-metallic material consisting essentially of silicates and aluminates of calcium and other bases. GGBS is also used as a binder component in geopolymer concrete.

Concrete, over years has proved to be one of the most indispensable materials for civil Engineers, considering the quantity of concrete that goes into every construction. We are at a stage where our river beds are fast depleting and most of the natural sand is being consumed. In general, the demand of natural sand is quite high in developing countries to satisfy the rapid infrastructural growth. Particularly, in India natural sand deposits are being depleted causing serious threat to environment and as well as to the society. Increasing extraction of natural sand from river beds is causing many problems, loosing water retaining sand strata, deepening of the river courses, causing bank slides, loss of vegetation on the bank of rivers, exposing the intake well of water supply schemes, disturbs the aquatic life as well as affecting agriculture due to lowering of underground water table etc. are few examples.

Under these circumstances use of industrial by-products and sandy soil offers viable alternative as replacement to cement and fine aggregate. The major objective of this project is to reasonably come out with an optimum combination of various ingredients which can produce green concrete 'from the point of sustainability and economy'. For this, the use of sandy soil as a replacement to natural sand and supplementary cementing material namely Ground Granulated Blast furnace Slag (GGBS) as a replacement to cement for the production of concrete are used. This project presents the effect of the use of sandy soil as fine aggregate and GGBS as cementitious material in concrete. The experimental work is mainly concerned with characterization of materials, study of mechanical properties and workability of concrete. This project intends to throw light on the use of unconventional material for the production of concrete highlighting their benefits.

Geopolymer concretes (GPC) are a type of inorganic polymer composites, to form a substantial element of an environmentally sustainable construction and building products industry by replacing/supplementing the conventional concretes. The term geopolymer was first introduced by **Davidovits** in 1970s to name the three-dimensional

alumino-silicates material, which is a binder produced from the reaction of a source material or feedstock rich in silicon (Si) and aluminum (Al) with a concentrated alkaline solution. The source materials may be industry waste products such as fly ash, slag, red mud, rice-husk ash and silica fume which may be used as feedstock for the synthesis of geopolymers. The alkaline liquids are concentrated aqueous alkali hydroxide or silicate solution, with soluble alkali metals, usually Sodium- (Na) or Potassium- (K) based. High alkaline liquids are used to induce the silicon and aluminium atoms in the source materials to dissolve and form the geopolymeric binder.

1.2 GEO-POLYMERS

In 1978, **Davidovits** introduced the word 'GEOPOLYMER' to describe an alternative cementitious material which has ceramic-like properties. As oppose to OPC, the manufacturer of fly ash-ground granulated blast furnace slag (GGBS) based geo-polymer does not consume high levels of energy, as fly ash and slag are already industrial by-product. This geo-polymer technology has the potential to reduce emissions by 80%. Because of high temperature calcining is not required .These also exhibit ceramic-like properties with superior resistance to fire at elevated temperatures. Geo-polymer can be produced by combining a pozzolanic compound or alumina silicate source material with highly alkaline solutions. Fly ash, which is available abundantly worldwide from coal burning operations, is an excellent alumino-silicate source material, where as granulated blast furnace slag is a by-product produced from steel plants. In India, fly ash is currently under utilized; according to figures in the year 2000, 90 million tons per annum were produced but only 20-25% of it was effectively utilized in cementitious application. Typically, for ore feed containing 60 to 65% iron, slag production ranges from about 300 to 540 kg per ton of pig or crude iron produced. Lower grade ores yield much higher slag fractions, sometimes as high as one tone of slag per ton of pig iron produced. Steel slag output is approximately 20%, by mass, of the crude steel output.

Lately much research has highlighted the potential use of fly ash-based geo-polymer in concrete production. Geo-polymers have also been shown to have good bond strength to cement concrete; hence it is a good repair material with superior abrasion resistance. Fly ash and slag based geo-polymer/aggregate composites have superior performance compared to

cement concrete in certain areas such as resistance to sulphate attacks, and have lower creep and shrinkage than conventional concrete. Geo-polymers are generally believed to perform better than the conventional concretes in fire due to their ceramic-like properties. However, published research in fly ash-slag-based geo-polymeric is limited in the area of fire resistance and responses to elevated temperatures. Given that geo-polymer increases in strength after elevated temperature curing, the fire resistance of geo-polymer is likely to be superior than of cement concrete which loses most of its strength after elevated temperature exposed to about 800˚C.

Though significant research on geo-polymer, as a binder, has been done, its behaviour under elevated temperature conditions is yet to be understood clearly. This study investigates a composition and processing conditions on strength and heat resistant properties of geo-polymer binder prepared using class Granulated blast furnace slag with sand and sandy soil as fine aggregate for temperature exposures of up to 350˚C for different molarity of 3M, 5M and 7M.

The motivation for using GGBS as the main raw material is driven by various factors:

- It is cheap and available in bulk quantities.
- It is currently under utilized except for its use as an additive in OPC.
- It requires less water (or solution) for activation.

Comparison of conventional and geopolymer-based cements

Portland cement	Geopolymer cement
$CaO + SiO_2$ $Al_2O_3 + SiO_2$	$Al_2O_3 + SiO_2$
1450ºC	20-90ºC+ alkali silicate solution
Clinker phases	Si –O –Al –O
Hydration	Poly-condensation
C-S-H + Ca $(OH)_2$	Alumina-silicate 3D framework