CHAPTER 1

INTRODUCTION

A rapidly developing country like India has to cater to infrastructural developmental activity on a very large scale. To realise this gigantic task, major construction material, OPC has to be available in abundance. Scarcity and spiralling cost of OPC has an adverse effect on the development of the nation.

The production of OPC has to be hiked significantly in the near future to meet its ever increasing demand. All human activity results in some degree of environmental degradation. The challenge is to minimise this degradation to a level consistent with sustainable development. There is an urgent need to limit the production of OPC for several reasons. The world consumption of portland cement has risen from less than 20 million kN in the year 1880 to 13 billion kN in 1996. Cement production is responsible for quick exhaustion of highly valuable natural resource, lime stone at the rate of 15 kN for each kN production of OPC. Manufacture of OPC is highly energy intensive, requiring considerable amounts of both fossil fuel and electrical energy. Unfortunately, the production of OPC releases large amounts of carbondioxide (CO₂) into the atmosphere. Because this gas is a major contributor to the greenhouse effect and global warming of the planet, the developed countries are considering very stringent regulations and limitations on CO₂ emission. About 7% of the world's CO₂ emission is attributed to the OPC industry (15). Spiralling cost of OPC is slowing down the process of development of the country.
In view of the global sustainable development, it is imperative that supplementary cementing materials be used to replace large proportion of OPC in the concrete industry in the coming years. The most abundantly available supplementary cementing material is fly ash, and others are blast furnace slag, silica fume, and rice-husk ash. A satisfactory resolution of this concern is the use of substitutes to OPC. Blended cements, portland slag cement (PSC) and portland pozzolana cement (PPC) using industrial wastes, blast furnace slag and fly ash respectively are known for overwhelming technically beneficial attributes. The blended cements though produced at lesser costs in the country, are sold in the market at nearly the same price as OPC.

The search for economical substitutes to OPC continues. In the year 1986, CANMET\textsuperscript{(15)} developed a concrete incorporating large volumes of fly ash. The so-called high-volume fly ash (HVFA) concrete has all the attributes of high performance concrete, i.e. excellent mechanical properties, low permeability and superior durability. It is a promising alternative to OPC in specified areas in the concrete industry, besides being highly economical.

Using three industrial wastes fly ash, lime, and gypsum, hydraulic cement (FaL-G cement) analogous to OPC has been produced\textsuperscript{(1-9)}. Abatement of pollution, lower energy requirements, conservation of valuable mineral resource, lime stone, and high economy are the attributes of FaL-G cement. Using FaL-G cement mortar comprising of FaL-G cement and sand, bricks analogous to burnt clay bricks are manufactured currently\textsuperscript{(6-9)} and these are used extensively in the construction industry in place of burnt clay bricks. Application of FaL-G cement in structural concrete was first attempted at Andhra University, Visakhapatnam, India\textsuperscript{(10-14)}. The cost of FaL-G cement is about
50% of that of OPC. The present research programme was undertaken to investigate the strength and behaviour of conventionally reinforced concrete beams with FaL-G cement under pure bending and shear.

The experimental study of this investigation comprised two parts. The first part consisted of tests on sixteen rectangular beams in pure bending in four series. The variable among the four series was cementitious binder. The binder in the first series was FaL-G cement. In the second and third series, the binders were PFaL-G cement and SFaL-G cement. These two binders that are modifications of FaL-G cement, were devised to investigate whether any improvement would result in the deformational behaviour of the structural members made out of FaL-G cement. The fourth series related to OPC as binder for comparison with the other three binders. Each series consisted of four beams. The variable in each series was amount of flexural reinforcement. The amount of reinforcement provided in the beams of different series were, minimum reinforcement, under reinforcement, balanced reinforcement and over reinforcement. All the beams had nominally the same cross-sectional dimensions, 150 x 250 mm and same flexural span of 2.3 m. The nominal grade of concrete adopted for all the binders was M20.

The second part of the investigation was devoted to the study of beams in shear without web reinforcement. A total of eighteen beams in three series were tested to failure in shear. The variable in each series was shear span / depth ratio (a / d). Six a/d ratios were adopted; they were 2.0, 2.5, 3.0, 3.5, 4.0, 5.0. All the beams had nominally the same cross-sectional dimensions, 150 x 250 mm and the span varied in accordance with a/d ratio. The percentage of longitudinal reinforcement in all the beams in the
shear investigation was 2.2.

Measurements were made of transverse load, transverse deflection, crack width and support rotations. Theoretical bending analysis was made using Indian Standard Code, IS: 456-1978 to predict the ultimate strength of flexural members. To estimate the shear strength of the beams, IS : 456-1978 , American code ACI 318-1995 and other predictor equations were used.

Comparisons were presented for theoretical and test results and the agreement was generally found to be good.

The research undertaken has established that FaL-G cement made from industrial wastes that is analogous to OPC, can be applied in structural concrete, with utmost economy.

It is estimated that FaL-G cement fabricated in the laboratory costs about 50 percent less than OPC.