INTRODUCTION

1.1 GENERAL

‘Shelter’ is one of the basic needs of any civilized society and it is the construction industry which helps to realize the ‘dream of having a shelter’ for the human race, in this world. On an average, the cost of building materials for the structure could be as much as 80%, depending upon the country where the construction occurs [Day, 1992, and Berhane, 1987]. It has been estimated (as on 2001), that the housing shortage in India, is 19.4 million dwelling units. The high-cost of building materials in many developing countries, including India, has resulted in the overall high-cost of construction and hence, having a ‘satisfactory shelter’ has been made beyond the reach of the majority of the population of the above countries. Hence, there will be a widening gap in the demand for housing units, unless, sincere and dedicated efforts are taken to reduce the ‘overall cost’ of construction.

Concrete is recognized as the mostly widely used engineering material, due to its formability and the availability of its ingredients. It is estimated that about 2 tonnes of concrete is placed per year per capita in the world. The global cement production has been estimated (as of 1995), to be about 1400 million tonnes. In spite of record production of cement in India during the past few years, the cost of cement has increased several times, during the last decade. Production of cement, in general, is energy-intensive and consumes the available natural resources in abundant quantities. Moreover, for each tonne of cement produced, about one tonne of CO₂ is released into the atmosphere, contributing to the ‘green house effect’, which in turn affects the ‘global climate’, adversely.

‘Fly ash’ is the largest industrial waste produced worldwide, resulting from the combustion of pulverized coal in thermal power plants. Nearly 70% of the power required for developed and developing countries, is produced from coal-fired thermal power plants. Due to rapid industrialization and urbanization, the demand for power generation has increased several folds, not only in countries like USA, but also, in developing countries like India and China. It has been estimated that fly ash
modern society has become increasingly environment-conscious and hence, the emphasis on ‘sustainable development’ during this century. In some developed countries, environmental regulations have been made very stringent, especially, for the disposal of fly ash and other types of wastes. It is therefore, imperative that supplementary cementitious materials (SCMs) like fly ash have to be utilized in ‘high to very high volumes’ in Civil Engineering applications, to overcome the economic and ecological problems associated with disposal of industrial wastes and to reduce the cost of materials used in construction. It has been identified in USA and in India that cement-based materials can consume most of the fly ash generated and hence, efforts in the last decade were directed towards increasing the use of high-volumes of fly ash.

However, the important requirement in using SCMs, especially, fly ash in high-volumes is that the strength of mortar / concrete should not be inferior to that of normal Portland cement concrete (NPC) at any age, with special emphasis on early age strength. Recent research shown that the ‘pozzolanic activity’, can be accelerated to attain high early-age strength, by ‘activation’ of fly ash. Lime and gypsum has been used as activators, apart from alkali-based chemical activators. (i.e. chlorides, sulphates, oxides of sodium, potassium and calcium). Strength acceleration by the addition of gypsum to fly ash / pozzolan–lime mixtures has been known, but not much is discussed in the published literature, except, the evidence obtained by Turriziani and Schippa, [as reported by Malquori (1960)] and the positive role of gypsum to increase early-strength, as cited by Lea (1971).
Research has been initiated during the last decade to produce binder(s) using mostly industrial wastes. FaL-G (a blend of fly ash, lime and gypsum) was one such binder obtained by ‘activating’ fly ash, using lime and gypsum (Bhanumathidas, 1996). Research has also been carried out on the ‘activation’ of natural pozzolana, using ‘alkali-activators’ (Shi, 1993). However, systematic and comprehensive studies on the activation of fly ash, especially, on high-calcium fly ash has not been carried out and reported.

1.2 NEED FOR FURTHER RESEARCH

The research reported on alkali-activation of fly ash, has been limited upto its application as a mortar, using reagent grade chemicals and adopting higher than normal temperatures to accelerate the pozzolanic reaction. In the case of fly ash-lime-gypsum (FaL-G) blend, comprehensive studies on the strength and durability of FaL-G concrete, using materials ‘as available’ have not been investigated. Studies on high-calcium fly ash based mortar / concrete, in general, have not been that extensively carried out and reported, when compared to low-calcium fly ash-based systems. Hence, there is an immediate need to carryout comprehensive studies on the activation of high-calcium fly ash with lime and gypsum and demonstrate its potential use in Civil Engineering.

1.3 SCOPE OF THE PRESENT STUDY

Following were set as the scope of the present study:

(i) To understand the activation process of the high-calcium fly ash, for the selected activators, namely, lime and gypsum;

(ii) To determine the best / desired activator from among the two activators considered and their optimum dosage;

(iii) To study in detail the strength characteristics of high-calcium fly ash concrete activated with the ‘desired activator’;

(iv) To develop mix-proportioning methodologies for the above concrete, considering various water-binder (W/B) ratios, workability and aggregate-binder (A/B) ratios;
(v) To indicate possible applications of the above concrete, based on the strength and other characteristics of the above concrete in hardened state

1.4 ORGANIZATION OF THE THESIS

In Chapter 2, a comprehensive review of literature on the various properties of fly ash, work of earlier investigators on blended cement and on activated fly ash, effect of different curing regimes and aggressive environments on fly ash concretes, are presented.

Chapter 3, presents the characterization of materials used in the study.

In Chapter 4, the preliminary investigations on the compressive strength characteristics of pastes, mortars and concretes of three blends (fly ash-lime, fly ash-gypsum and fly ash-lime-gypsum) along with the identified optimum blend and the desired type of curing, are presented.

In Chapter 5, mix proportioning of the concrete using the type of binder identified and optimized in chapter 4, along with the results of the workability of the resultant concrete are presented.

In Chapter 6, various mechanical and thermal properties, the behaviour under aggressive chemical environments, elevated temperature and in boiling water of the above concrete, have been evaluated and discussed.

The salient conclusions based on the present study are presented in Chapter 7.