CHAPTER 1
INTRODUCTION

1.1. GENERAL

Fire causes thousands of deaths and loss of property loss every year. The need to understand the manner in which cement based materials such as concrete behave at elevated temperature is cardinal need for public safety.

Most concrete structures, under normal conditions are subjected to a range of temperature not more than that imposed by ambient climatic conditions. Process temperature is an extreme condition, under which concrete structure could be exposed to elevated temperatures. Examples of such cases may be jet aircraft engine blasts, building fire, industrial applications (furnaces), oil, gas, nuclear and power industries, concrete foundations for launching rockets carrying spaceships.

Structures will also be subjected to elevated temperature in accidental fires. Fire induced collapse of world trade centre in New York U.S.A, with heavy causalities has high lightened the importance of construction material is at elevated temperature. Similarly the great belt tunnel fire in 1994, and the channel tunnel fire in 1996, El-Akhdaria tunnel (Algeria) fire in 2008 are examples of concrete being exposed to elevated temperatures under fire upto10 hours.

Even though concrete is generally believed to be an excellent fire proofing material, many studies have shown extensive damage or even catastrophic failure at high temperature. Under such applications, study on the effect of elevated temperature on certain mechanical and physical properties may determine whether the concrete will be able to maintain its structural integrity. The durability and performance of based on
the performance of its constituents cement, aggregates, additives and water used in the concrete at elevated temperature:

1.2. CEMENT AT ELEVATED TEMPERATURES

Cement being one of the important constituents of concrete, it plays an important part on the durability and performance of concrete at exposure conditions. The changes in the microstructure or nanostructure of cement paste thus influence the macro properties of cement paste. An understanding of both chemical and physical changes caused by elevated temperature is required to evaluate the extent of thermal damage.

The mechanism that drives the thermal degradation of cement based composite materials still remains unresolved. It is an established fact that the behavior of concrete under elevated temperature is greatly dependent on its composites structure and in particular on the physical and chemical composition of the cement paste.

Physical and chemical transformation takes place in concrete at elevated temperature which can result in significant loss in strength. The bonding ability of concrete mainly depends on the cement matrix, any deterioration in hardened cement paste (hcp) will cause a decline in the bond between cement matrix and aggregates. Studies have shown that the thermal decomposition of hcp, micro cracking and pore structure coarsening are the main causes of any deterioration of concrete at elevated temperatures.

The main components of cement paste, calcium silicate hydrate (C–S–H) and calcium hydroxide (CH) dehydrate respectively at elevated temperature which causes an irreversible damage to cement paste. Therefore, the investigation of microstructure of heated Portland cement paste helps to understand the deterioration mechanism of cementitious materials at high temperature [1]. The microstructural changes can be investigated by recent material characterization techniques such as x-ray diffraction (XRD), scanning electron microscopy (SEM), Fourier transform infrared spectroscopy (FTIR), thermal conductivity etc. Using these techniques in cement chemistry research
has led to better understanding of cement properties, both at macro scale and micro scale. This also helps in developing chemical admixtures which are compatible with cement and also helps in reducing the deterioration caused by elevated temperature in concrete.

1.3. **NEED FOR PRESENT STUDY**

Cement paste undergoes significant changes when exposed to elevated temperatures resulting in changes in chemical composition and microstructure. The variation in chemical composition and microstructure of cement exposed to elevated temperature leads to formation of micro cracks, desiccation of pore structure, spalling and reduction in strength of concrete. These observations are based on literature review and it is more relevant to reduce the effect of elevated temperature on cement which indirectly enhances the thermal resistance of concrete. It has also been observed from the literature chemical and mineral admixtures have been developed to improve the properties of cement. Cement being an important constituent of concrete; it is important to understand the changes in properties when refractory materials are used as admixtures in cement. Limited studies are available on refractory chemicals as admixture in cement to reduce the effect of elevated temperature on concrete. Thus it is necessary to study the changes in chemical composition and the influence of refractory materials as admixtures in concrete and to identify suitable refractory material to limit the effect of elevated temperature on cement.

1.4. **OBJECTIVES**

- To investigate the extend of degradation of physico-mechanical properties of portland cement mortar under 5 different elevated temperatures, 100, 200, 400, 600 and 800 °C and for different durations of exposure (2,4,6 hrs)
- To improve the thermal resistance characteristics by of OPC, by identifying a suitable chemical admixtures, which are being used as refractory material, and investigating their compatibility with cementitious system. Eg: ZrO₂, TiO₂, Al₂O₃, SiC.
• To evaluate the physical properties OPC matrix with refractory, the parameters such as specific gravity, consistency, initial setting time, final setting time have been determined with different replacement level ie: 2%, 4% and 6% by weight of cement.

• To study the thermal stability of the blended mixes, tests on compressive strength of the mortar prepared in the temperature range 100-800 °C with exposure time of 2, 4, 6 hours by designing the suitable experimental program.

• To evaluate the extent of deterioration of the matrix at elevated temperature, thermal conductivity of OPC mortar with and without refractory chemicals was determined before and after thermal treatment using KD2 pro.

• To evaluate the extent of thermal degradation by studying the mineralogical changes at different temperatures by means of XRD.

• To study the correlation between the micro structural changes and the changes in compressive strength due to elevated temperature by means of SEM, EDAX and FTIR.

• To study the compatibility of the refractory chemical, having better thermal resistance in OPC, with OPC replaced with 20% class F fly ash.

• To study the thermal stability of the blended mixes, tests on compressive strength of the mortar prepared in the temperature range 100-800 °C with exposure time of 2, 4, 6 hours by designing the suitable experimental program.

• To evaluate the extent of deterioration of the matrix at elevated temperature, by determining the thermal conductivity of all the blended mixes before and after thermal treatment using KD2 pro.

• To study the effect of thermal treatment on mineralogical changes blended cement mixes with and without refractory chemicals using XRD, to study the correlation between the micro structural changes and the changes in compressive strength of blended cement mortars with and without refractory chemicals, due to elevated temperature, by means of SEM, EDAX and FTIR.

• To characterize the degradation of matrix of all the mixes through water absorption studies before and after exposure to temperatures of 100 – 800 °C for all durations of exposure.
1.5. SCOPE

Considering the objectives the following studies have been planned to know the performance of cement mortars at elevated on the addition of refractory chemicals.

- Study on the physical properties of cement mortar and blended cement mortar with the addition of refractory chemicals.
- Study on the mechanical properties of cement mortar and blended cement mortar with the addition of refractory chemicals after thermal treatment.
- Study on the morphological and mineralogical changes in cement mortar and blended cement mortar with the addition of refractory chemicals after thermal treatment.
- To study the above mentioned characteristics the experiments have been planned using
  a. Ordinary Portland cement (OPC) and blended cement (OPC+20% fly ash)
  b. Different refractory chemicals ZrO$_2$, TiO$_2$, Al$_2$O$_3$, SiC.
  c. Different percentages of refractory chemicals, 2%, 4%, 6%.
  d. Different levels of temperature 100°C, 200°C, 300°C, 400°C, 600°C, 800°C.
  e. Different levels of exposure 2 hour, 4 hours and 6 hours.

1.6. SUMMARY

The above discussions and illustrations in chapter 1 shows the necessity and importance for the studies on the behavior of cement in concrete at elevated temperatures. Chapter 2 deals with the literature review of the work.