Conventional cement concrete (CCC) is the most extensively used construction material world-wide, whether in moderately aggressive environments, or in strongly aggressive environments. This is due to the fact that with water resistance it can be moulded in a variety of shapes or sizes. It is cheaper and more easily available in the field. To illustrate this statement, Metha and Monteiro (1999) examined the world consumption of concrete which reaches the order of 5.5 billion tonnes a year.

The advance of concrete technology, as well as the development of new materials and components has resulted in increased performance and strength needs, which were not adequately satisfied any longer. Maintenance, repair and rehabilitation of existing cement concrete structures also involve a lot of problems causing significant expenditure. Hence, there is an urgent need to pay more attention for improving the properties of concrete with respect to strength and durability, especially in aggressive environments.

High performance concrete (HPC) appears to be a better choice for a strong and durable structure. It is also a cement concrete which has far superior strength and durability characteristics compared to CCC. HPC does not mean only achieving the specified compressive strength but also other parameters such as impermeability, resistance to environmental factors, shrinkage, corrosion resistance, electrical resistivity etc. Suitable addition of pozzolanic/mineral admixtures such as silica fume (SF), ground granulated blast furnace slag, rice husk ash, fly ash and highly reactive metakaolin in concrete improve the strength and durability of concrete due to considerable improvement in the microstructure of concrete composites, especially at the transition zone.
HPC is generally cement based composite and can be produced using the mineral and chemical admixtures. It can be considered as an appropriate material for the construction of large infrastructures. Presently, considerable research and development is being carried out in many countries, thanks to the development of HPC and its use in many structures, especially, high rise buildings, highway bridges, nuclear structures, pavements, dams, marine structures, tunnels and pre-cast units is increasing tremendously.

Very few studies have been reported in India on the use of silica fume for development of HPC and also durability characteristics of these mixes have not properly been reported. Investigations were being carried out in order to make a quantitative assessment of different cement replacement levels with silica fume on the strength and durability properties of M60, M70, M80, M90, M100 and M110 grades of HPC trial mixes and to arrive at the optimum levels of replacement of cement with silica fume.

In this present investigation, silica fume in dry densified form has been used as the mineral admixture for partial replacement of cement and a superplasticizer by the name Conplast SP 430 has been used as the chemical admixture. Silica fume in small percentage improves the mechanical and durability characteristics of concrete. Addition of high range water reducing chemical admixture known as superplasticizer improves the workability of concrete and thus making it possible to get sufficient workable concrete at lower water - binder (w/b) ratio.

There were several attempts to develop a method for the proportioning of mixes with cement replacement material (CRM), which could be classified as addition, replacement or rational methods. Existing methods of mix proportioning are not adequate for the optimization of many factors that must be considered for HPC. Therefore, a simplified and modified mix design procedure based on the BIS and ACI methods of concrete mix design and the available
published literatures on HPC, has been formulated in this thesis. The HPC mixes M60, M70, M80, M90, M100 and M110 grades were designed using the above formulated mix design procedure and experimental investigations were carried out to verify the proposed mix proportioning method.

In this dissertation, investigations were carried out on mechanical properties such as compressive strength, splitting tensile strength, flexural strength, modulus of elasticity and flexural toughness and on durability properties such as saturated water absorption, porosity, sorptivity, permeability, acid resistance, sea water resistance, abrasion resistance, impact strength, rapid chloride penetration, corrosion resistance and alkalinity measurement of M60, M70, M80, M90, M100 and M110 grades of HPC trial mixes by replacing 0 to 15 percent of the mass of cement with silica fume at a constant dosage (three percent by weight of the binder contents) of superplasticizer. The results of the investigations demonstrate the superior mechanical and durability characteristics of silica fume-based concrete mixes. Based on the results obtained, the optimum percentage of replacement of cement with silica fume, which yields superior mechanical and durability characteristics was arrived at. The details of the investigations along with the results are presented in this thesis.