CHAPTER 3

OBJECTIVES AND SCOPE OF PRESENT INVESTIGATIONS

3.1 Introduction

From the brief literature survey conducted in this investigation it may observed that though lot of work on the study of Mode-I fracture and limited work on Mode-II fracture of concrete is carried out, very limited work is reported on the study of Mode-II fracture of concrete using crushed stone fine aggregate, high density coarse aggregates and pozzolonic materials etc., Also the Double Central Notched (DCN) specimen geometry proposed by Prakash Desai et al. [1] and Bhaskar Desai [2] is supposed to be best suited specimen geometry for Mode-II fracture of concrete. In the light of above, present investigation on Mode-II fracture of concrete using DCN specimen geometry is carried out.

The recent advances in the cement concrete industry has led to utilize different industrial by products as a part of cement concrete in economizing the cost of cement concrete and thereby cost of construction, decreasing the disposal problems of industrial by-products, effective utilization of natural resources and to reduce the emission of CO$_2$ during the manufacture of cement. Also the utilization of higher grade concrete requires high strength coarse aggregate, in this concern high strength metallic coarse aggregate hematite can be considered to be one of the best suited material in place of conventional coarse aggregate granite metal.

Though the mechanical properties and scanty Mode – I fracture characteristics of the concrete made with the industrial by-products such as crushed granite stone fine aggregate from the granite crushing industry as a partial/complete alternative material in place of natural river sand,
fly ash as a partial replacement material in place of ordinary Portland cement, micro silica as a partial replacement in place of ordinary Portland cement and hematite metal as a partial/complete replacement in place of the conventional granite coarse aggregate material, are available in literature, but there is no literature related to Mode – II fracture characteristics of such concretes are available. Hence in this concern, a limited experimentation attempt is made to study the Mode – II fracture characteristics of such concretes along with their compressive strength and split tensile strengths. The material inhomogeneity in the above concretes, which leads to variations in strength and fracture characteristics are considered by randomizing the crack initiation, ultimate loads and corresponding deformations in Mode – II fracture.

3.2 Concrete with crushed granite stone fine aggregate, partially/completely replacing the conventional fine aggregate, natural river sand

Rapid civilization and increase in population in the last few decades caused an extensive increase in construction activity in the world. In some regions especially in scanty rain fall areas this caused the scarcity of good quality of river sand. The durability of concrete directly depends on the quality of sand. With a view to implement sustainability concepts (namely, use of locally available materials and industrial by-products) in the concrete construction industry, the possible use of machine crushed granite stone fine aggregate (from here after known as crushed stone fine aggregate), which is a by-product obtained from the granite machine crushing industries in the production of granite as coarse aggregate in different specific required sizes, is considered as an alternative material to river sand in concrete. In certain design situations to impart adequate shear resistance (viz. flat slabs, concrete foundations carrying heavy loads, containment structures) understanding of Mode - II fracture behavior of concrete is important.
From the brief review of literature (Section 2.4) related to use of crushed stone fine aggregate in concrete presented above, it is noted that the crushed stone fine aggregate and dust can be advantageously used as replacement of natural river sand in optimal quantity depending on grading of the aggregate. While the above studies have focused on examining the suitability of crushed stone fine aggregate and dust in improving the mechanical properties of concrete such as compressive strength, flexural strength, split tensile strength, modulus of elasticity, but the investigations related to Mode - II fracture behavior of crushed stone fine aggregate concrete has not been paid much attention. Hence the present experimental investigation in that direction has been attempted by replacing the natural river sand with crushed stone fine aggregate in concrete in percentages of 0, 25, 50, 75 and 100 by mass and its characteristics in Mode –II fracture along with mechanical properties such as compressive strength and split tensile strength are to be studied.

3.3 Concrete with hematite as a coarse aggregate, partially/completely replacing the conventional coarse aggregate, granite metal

The structural elements such as footings of columns and flat slabs subjected to concentrated loads from the columns, foundations of bridge receiving loads form piers, blast resistant structures such as bunkers and nuclear containments subjected to external punching attacks, runway pavements which are subjected to impact loads while landing of planes, are need to be designed to with stand against the occurring stresses safely. In such structural elements, if the concrete used contains the conventional locally available coarse aggregate, it will lead to usage of higher volume of concrete to withstand higher stresses. In this concern, high performance concretes are developed to suite the specific needs of the construction industry. But for high performance concrete, which has generally lower water – binder ratio and higher strength, the
strength of cement paste and the cement – aggregate bond strength is often higher than that of aggregate. Consequently, the influence of type of aggregate plays a dominant role in such high performance concretes.

Limited number of the researchers in different parts of the world (Section 2.5), have conducted experimental investigations related to the use of hematite metallic aggregate as a coarse aggregate in cement concrete made with partially/completely replacing the conventional coarse aggregate granite metal in different percentages, from their experimental studies, it is noted that the metallic coarse aggregate hematite can be advantageously used in high strength concrete (Keru Wu et al.[48]). While the above studies have focused on examining the suitability of hematite aggregate in improving the mechanical properties of concrete such as compressive strength and split tensile strength and also Mode – I fracture characteristics, but the investigations related to Mode - II fracture behavior of such concrete are scanty.

From the brief review of available literature (section2.5), it is observed that the limited available studies on the concrete made with hematite as a part coarse aggregate have not focused attention on its Mode – II fracture characteristics. Hence the present experimental investigation in that direction has been attempted by replacing the conventional granite coarse aggregate with hematite aggregate in percentage of 0, 25, 50,75 and 100 by mass and its characteristics in Mode – II fracture along with mechanical properties such as compressive strength and split tensile strength are to be studied.

3.4 Concrete with fly ash as a cementitious material, partially replacing the ordinary Portland cement in concrete
In mass concrete structural elements (Ex. Footings of heavy loaded columns, flat slab drop panels, deep beams etc.,) the rate of dissipation of heat of hydration is very slow process. This will induce early age cracking, which has become a serious concern. The increase in member size and increased cement content for high strength concrete, have drawn major concern due to the risk of thermal cracking and autogenous shrinkage in the members. Heat of hydration is the main factor which influences the thermal cracking and autogenous shrinkage in the structural elements. The crack tips become potential sources for stress concentrations in the structures, causing further growth of the crack under service loads with time, thereby decreasing the designed load carrying capacity. To reduce the heat of hydration, different supplementing pozzlanic cementitious materials are generally considered as partial replacements for cement in concrete, which are by-products from different industries posing problems in their disposal. The usage of these industrial by-products when used along with cement in concrete industry, it not only reduces the heat of hydration but also decreases the concrete production cost.

From the brief review of the available literature presented (section 2.6) on the fly ash concrete, investigations related to evaluation of Mode – II fracture energy of concrete partially replacing the cement with fly ash has not been paid much attention. In the light of this, the scope of using the industrial by-product such as fly ash is considered as the supplementing cement material in concrete in various percentage replacements of 0, 5, 10, 15, 20,25 and 30 by mass in place of cement, and the fracture characteristics of the concrete in Mode-II fracture is thought to be examined along with its mechanical properties such as compressive strength and split tensile strength.

3.5 Concrete with silica fume as a cementitious material, partially replacing the ordinary Portland cement in concrete
The structural elements subjected to heavy concentrated loads, such as column footings and flat slabs, require high strength and durable concrete against punching shear failures and aggressive environmental and loading conditions. In this concern, the use of various reactive pozzolanas as supplementary cementitious materials are fast growing in the development of concrete with high strength and durability. One of the possible ways for making the concrete with high strength and durability is by partially replacing the cement in concrete with industrial by-product such as silica fume along with the water reducing agents. This silica fume not only plays an important role to act as a filler in concrete due to its fine particle size, but also its pozzlonic nature makes it able to react with free lime, leading to formation of hydro – silicates, which ultimately not only improve the mechanical properties of concrete but also its durability against aggressive environmental and loading conditions.

Though number of experimental investigations are available in literature (section 2.7) with silica fume modified concrete, they are limited to the study of mechanical properties and Mode – I fracture studies of concrete only. In view of this, the scope of using silica fume as a supplementing cement material by partially replacing the ordinary Portland cement in concrete with different percentage replacements 0, 5, 10, 15, 20, 25 and 30 by mass are considered and its characteristics in Mode-II fracture and its mechanical properties such as compressive strength and split tensile strength are to be examined.

From available literature, it can be observed that, from the experimental results on Mode – II fracture characterization of concrete with different specimen geometries, Prakash desayi et al.[1] and V.Bhaskar Desai [2] has arrived that, the DCN specimen geometry (Fig.1.4) which fails in predominant Mode – II fracture is considered to be the best suited one for the characterization of Mode – II fracture concrete. It is also to be observed from the literature that, the results obtained
from the numerical simulations on shear fracture process of concrete using mesoscopic mechanical model done by W.C.Zhu and C.A.Tang [5] on DCN specimen models are quite closer to the experimental results of Prakash Desayi et al. [1] and Bhaskar Desai[2].

Hence for the present experimental study for Mode – II fracture characterization of concrete made with above mentioned industrial by products and also with hematite metallic coarse aggregate in different proportion replacements, DCN specimen geometry Fig.1.4 proposed by Prakash desayi et al.[1] and Bhaskar Desai[2] is considered with different notch to depth ratios (a/w) of 0.3, 0.4, 0.5 and 0.6. To account the variations of material inhomogenity and randomness in crack propagation in Mode – II fracture process of these concretes, probabilistic approach is considered using Monte Carlo simulation technique for the characterization of fracture energy. It is felt that the results of these studies are useful in better understanding of the Mode – II fracture characteristics of concrete made with

(i) Crushed granite stone fine aggregate partially/completely replacing the conventional fine aggregate natural river sand.

(ii) Hematite coarse aggregate partially/completely replacing the conventional coarse aggregate granite metal.

(iii) Fly ash partially replacing the ordinary Portland cement.

(iv) Silica fume partially replacing the ordinary Portland cement.