CHAPTER 2

LITERATURE REVIEW

2.1. INTRODUCTION

The use of recycled aggregate in concrete is gaining momentum. In the future, the recycled aggregate concrete (RCA) may become the need of the day. With an increase in our environmental consciousness, the concrete industry is coming under intense scrutiny and criticism. Many practices within the concrete industry that pose a potential threat to our environment are becoming matters of serious concern and along with increased consumption, there is also an increase in the amount of waste that concrete using societies have to deal with (Prakash, et. al. 2006).

In the construction industry, in urban areas, the demolition of old structures is on the rise either because they are obsolete, unsafe, need repair and rehabilitated or else to make a way for newer, larger, taller structures. As a result, large amount of demolished concrete is generated as waste and is disposed off by dumping it as landfill or off reclaiming the land. But the cost of transportation and the shortage of dumping grounds make disposal a major problem (Ravindrarajah, 1987).

At the same time due to increasing urbanization the natural resources are depleting. It is becoming increasingly difficult to obtain good quality aggregate at reasonable prices. The increase in cost is mainly due to the cost of transportation and due to fewer quarries. Furthermore, out of
concern for the environment mining of fresh quarries has been prohibited (Jackson, 2003). Considering the present situation, the best solution would be to reuse the demolished concrete. Utilization of recycled aggregate is widely accepted for the pavement, base and sub base courses and to some extent for foundation purpose.

As a further scope towards the use of waste concrete, the concrete rubble is being used as a substitute for natural aggregate have shown that recycled concrete can best be used as a substitute for coarse aggregate only (Nagarajan, 2004). Dhir, et. al. (1999) examine the suitability of recycled concrete aggregate (RCA) for use in BS 5328 designated mixes. The results for the aggregate characteristics showed that plain as well as reinforced demolished concrete debris can be crushed using existing plant to provide RCA of physical properties that satisfy the current BS882 requirements. The density of both fine and coarse RCA was found to be lower than that of natural aggregate (NA) and water absorption was three to six times higher.

Conventional concrete and HPC differ considerably from each other. HPC is a multi component material; hence, special attention need to be paid for the selection of appropriates materials and selection of mix proportions of various ingredients (Neville, et. al., 2000). It is also equally important that the production methods, i.e. mixing, handling, placing, compacting and curing are also executed carefully.

2.2. MECHANISMS OF HYDRATION

The interactions of silica fume and fumed silica with the cement particles can be classified as physical and chemical. The former, which are called “micro filler effect”, consists of filling the spaces between the cement particles by the silica fume or fumed silica. The later called the “pozzolanic
effect”, follows from the reaction of the silica fume or fumed silica with the Portland cement produced by the hydration of the silicates giving the silicate hydrate gel (C-S-H). Regarding the influence on the hydration process, several authors (Ramachandran, 1984) report an acceleration of hydration of the anhydrous silicates of the cement in the presence of silica fume. The fine silica fume particles appear to act as nucleation points, (Monterior, et. al., 1986) leading to a finer porosity as well as denser and homogenous matrix. When silica fume is incorporated, the rate of cement hydration increases at the early hours due to the release of OH ions and alkalis into the pore fluid (Larbi, et. al., 1990). The increased rate of hydration may be attributed to the ability of silica fume to provide nucleating sites precipitating hydration products like lime, calcium silicate hydrates. Silica fume influences early hydration by accelerating the hydration of the tri calcium silicate (Cheng-Yi, et. al., 1985).

Bentz, et. al., (1991) demonstrated that both the size and the reactivity of the pozzolonic admixtures are important in producing a uniform microstructure of cement paste throughout the concrete. Highly reactive admixture such as silica fume exhibits the greatest positive influence on the microstructure of the interfacial zone. Kadri, et. al., (2001) and Cohen, et. al., (1986) evaluated the influence of silica fume on the rate of heat liberation and the accumulated heat in high –performance concrete. Portland cement was replaced by silica fume in amounts from 10% to 30% in concrete with water-binder ratios varies between 0.25 to 0.4.

Pinto, et. al., (1999) investigated influences of silica fume and superplasticizer on the heat of hydration of mortar mixtures with low water-cementitious material ratios. Superplasticizer and silica fumes were both found to be significantly affecting the heat characteristics of the mixtures. Silica fume increases the early heat of generation, whereas superplasticizer retarded the early heat of generation. Yogendran, et al (1987, 1991) studied the
effect of silica fume on high and low water-binder ratio with respect to hydration process of cement paste and concluded that the higher the water cement ratio, more is the requirement of silica fume to consume all the Ca (OH)$_2$.

The formation of denser matrix and interfaces leads to a significant increase in the strength of the concrete due to the incorporation of silica fume (Rosenberg, et. al., 1991). This is mainly produced by the micro filler effect as demonstrated by Goldman, et. al., (1994) by comparing the strength of silica fume concrete and non pozzolonic micro filler. The strength of silica fume concrete has always been higher than silica fume paste. In cement concrete, the aggregates function as inert filler, due to the presence of weak interfacial zone. But in silica fume concrete, the presence of silica fume eliminates this weak link, by strengthening the cement paste aggregates bond and forming a less porous and more homogeneous microstructure in the interfacial zone (Bentur, 2002). This may lead to an increase in the concrete strength over that of its paste matrix.

Addition of fumed silica enhances the rate of cement hydration at early hours due to the release of OH$^-$ ions and alkalis in the pore fluids. Fumed silica accelerates both C$_3$S and C$_3$A hydration during the first few hours. Calcium silicate hydrates (C-S-H) plays a vital role in influencing the characteristics of cement paste. Hydration proceeds faster in pastes with fumed silica, due to both CH and non-evaporable water contents at the early ages of 3 and 7 days. However, the hydration reactions in mortar terminate earlier. After 28 days the non-evaporable water content continues to increase significantly in plain cement concrete.
2.3 SELECTION OF MATERIALS

2.3.1 Cement

With a given high-quality aggregate, the strength and permeability of concrete mixtures are controlled by the quality of the cement paste, which in turn, depends on the physical and chemical characteristics of the cement type and dosage of chemical and mineral admixtures, the original water-cement ratio, and the degree of hydration. Freyne, et. al., (2004) examined the two classes of high performance concrete mixtures that were designed to achieve compressive strengths of approximately 60 and 75 MPa at 28 days respectively. Criteria for comparing mixtures included workability, compressive strength, splitting tensile strength, and modulus of elasticity. Mixtures containing type III (rapid hardening) cement shows highest compressive strength at all ages, tested most significantly at early ages, when compared to type I (Portland) and type II (modified). ASTM type II cements were ground to a higher fineness than the normal type are generally well suited for making HPC (Mehta, et. al., 1990).

2.3.2 Aggregates

In addition to cement paste – aggregate ratio, aggregate type has a great influence on concrete dimensional stability. Concrete mixtures containing coarse aggregates derived from limestone or basalt are generally known to perform very well in HPC (Cetin, et. al., 1998). Use of well-graded clean aggregates that are free from silt, clay and friable particles is often overlooked in case of normal concrete mixes. However, in HPC this cannot be overlooked. Fine aggregates (<0.475 cm) with a medium-to-high fineness modulus between 2.5 to 3.0 are generally considered to be adequate. Coarse aggregate should have equidimensional particles; Generally 10 to 14 mm size is considered as optimum for HPC. (Pilar, et. al., 1996 and Tasdemir, et. al., 1996)
2.3.3 Admixtures

It has been reported that the pozzolonic reaction of silica fume is very significant at low water-cementitious ratios with the addition of the silica fume (Zhang, et. al., 1991). Silica fume is a pozzolonic material widely used in concrete mixtures. It increases paste strength due to the pozzolonic activity and leads to a refinement of the pore structures and to a better bond at the aggregate-paste interface. The admixtures interact with the hydrating cementitious system by physical, chemical or physio-chemical action, modifying one or more properties of the concrete, mortar or paste in the fresh, setting, hardening or hardened stage. (Villarreal, 1997) Materials such as fly ash, slag, pozzolanas or silica fume which can be constituents of cement and/or concrete. Incorporation of mineral admixtures can lead to benefits like improvement in rheological properties. Paste provides numerous nucleation sites for hydration and improves impermeability of concrete and hence, their presence as an ingredient in HPC is unavoidable.

Superplasticizer or high-range water reducing admixtures are incorporated in the concrete in order to reduce significantly the water-cement ratio while maintaining the workability or increasing the workability at a constant water-cement ratio. The superplasticizer molecules are adsorbed on the surface of cement particles, hindering their flocculation due to the generation of repulsive forces, which are electrostatic and/or offer steric hindrance (i.e. maintain the cement particles apart due to lateral molecular chains). Consequently, the particles are homogeneously distributed in the aqueous solution, minimizing the amount of water needed for them to be disposed, which leads to the higher fluidity/workability of the concrete (Aitcin, et. al., 1994).
2.4 MIX PROPORTIONING FOR HPC

Several researchers have proposed modifications to conventional proportioning methods. Mehta et al (1990) and ACI committee 363 reports provide an excellent review of proportioning considerations for HSC. Selection of the proper raw materials and adjustment of proportions based on experience, using mixes conducted both in the laboratory and in the field, have typically proven adequate to achieve the desired concrete characteristics, at least within the limits allowed by the available raw materials. With adequate control of production and placement, routine use of concrete with compressive strengths in excess of 60 MPa is practical in many areas.

Several articles have been published with suggestions on the methods of optimizing the development of particular mixes, by reducing the number of trial mixes. Development or adaptation of new types of HPC or combination of raw materials are better served by engineering techniques than by more sophisticated proportioning techniques. Aitcin (1990) proposed a very simple method which can be used for both air entrained and non-air entrained HPC. Francois de Larrard et al (2002), proposed a mix proportioning for HPC, considering packing density and segregation ability of dry packing particles. They focused on the properties of fresh concrete and the mechanical properties of hardened concrete using a model of aggregate particles surrounded by a cement-based matrix.

The process of HPC mixtures selection can be greatly improved by employing statistical techniques that can optimize multivariable systems, especially if more than one response is of importance. The two primary techniques that can be used for optimization of a multivariable system include the Mixer method and Response Surface Methodology (Meyers, et. al., 1995). The advantages and disadvantages of both of these techniques have been

Bharathkumar, et. al., (2001) suggested a modified mix design procedure to the ACI method of normal concrete mix design utilizing the ‘efficiency factor’ of the mineral admixtures. Alves, et. al., (2004) studied four proportioning methods, one being conventional concrete and three specifically for high strength concrete. The objective of mix proportioning method is to determine an adequate and economic rate for the concrete making materials. From the results obtained, ‘mix proportioning diagram’ and ‘modeling of concrete’ was presented for the values of water cement ratio, aggregate cement ratio and cement content per cubic meter. Ghezal, et. al., (2002) studied the mixture proportions of concrete involving the combination of material constituents to satisfy various requirements of fresh and hardened concrete properties at minimum cost. Derived statistical response models could significantly reduce the effort required to identify concrete mixes at relatively low cost. Demaro, et. al., (1997) studied a five variable statistical experimental design to optimize the effect of the main components of performance, strength and economy of the mixture.

Swamy (1997), reported that the simplest approach to mix proportioning with fly ash and slag concrete is direct partial replacement of portland cement by mass, and modification of mixture proportions to suit strength and workability requirements for a given application.
2.5 FRESH CONCRETE

Silica fume, fumed silica and super plasticizers affect early cement hydration differently. Silica fume has been shown to accelerate cement hydration. Superplasticizer has been reported to retard the early hydration of cement (Chang, et. al., 1996) depending on the plasticizers type, amount, and mode of use. The influence of super plasticizers and silica fume acting together has been studied by Johnston, et. al., (1979) and Pinto, et. al., (1999) and it was observed that at all levels of silica fume, increasing the amounts of superplasticizers retarded the heat generation behavior of the mixtures.

It is recommended that superplasticizers or HRWR should only be used in HPC. Superplasticizers are produced from the derivate of naphthalene or melamine. The properties of fresh concrete reviewed by Malhotra (1981) includes bleeding and segregation, increase in slump and its subsequent loss with time, initial setting time, entrained air content, effect of repeated dosages, vibration requirements, and pump ability of super plasticized concrete.

Mehta (1999) has explained that silica fume is an industrial by-product with a particle size of about 100 times finer than OPC. This material which is highly pozzolonic, also creates a greater water demand or the use of a high range of water reducer. Yunxing shi et. al., (2002) reported that the partial replacement of cement with silica fume improves the fluidity and rheological property of HPC. Up to 12% of silica fume content, plastic viscosity and yield stress became the maximum, and concrete had the lowest fluidity. Roncero et al, (2002) reported that the addition of 5% of silica fume by weight of cement leads to a significant increase in the superplasticizer demand due to higher specific surface area.
Shigihalli et al., (2002) have concluded that the workability of concrete as measured from slump, compaction factor and Vee-bee degree decreases as percentage of silica fume in concrete increases. They also concluded that as compared to the normal mix, silica fume concrete has a slump reduction of 28 percent and compaction factor reduction of 5.26 percent. Caldarone et al, (1994) observed that although the slump of the concrete containing 10% metakaolin was reduced from that of concrete with OPC, the metakaolin concrete required 25 to 35% less high-range-water-reducers (HRWR) than those of equivalent silica fume mixes. This reduction in HRWR demand resulted in the metakaolin concrete having less sticky consistency and better finish than the silica fume concrete.

Zhang et al, (1995) reported that the quantity of superplasticizer required for 10% metakaolin incorporated concrete was same as that of silica fume concrete but setting times of metakaolin concrete was shorter than normal and silica fume concrete. Sabir et al, (1996) reported that although it was clear that metakaolin increased water demand, the standard workability (ie., slump, compaction factor and Vee-bee time) was not capable of quantifying the influence on the overall flow properties of metakaolin concrete, particularly at the lower water-binder (w/b) ratios. Bai et al, (1999) observed that there was a systematic decrease in both slump and compaction factor and a systematic increase in Vee-bee time as the OPC replacement level by metakaolin in their concrete mixes increased from 0 to 15% and there were larger changes in workability of the concretes with the high water binder ratios.

Duval. et. al., (1998) investigated the workability and the compressive strength of silica fume concrete at low water-cementitious materials ratios with sulphonated naphthalene superplasticizer. The results show that partial cement replacement up to 10% of silica fume does not reduce the concrete
workability. Jeyabalan, P (2004) reported that use of fumed silica in concrete increased the water demand. The standard workability test, i.e., slump, compacting factor and Vee-bee time, were not capable of quantifying the influence on the overall flow properties of fumed silica concrete with Recycled concrete aggregate, particularly at the lower w/b ratios (w/b=0.32).

2.6. EFFECTS OF CURING OF CONCRETE

Curing of concrete is widely recognized as an essential factor for producing concretes and this determines the subsequent performance. There are a number of techniques that are now available which either reduces the loss of moisture or provides an additional supply at early ages. For preventing moisture loss or promoting continued hydration, refinement of the permeation properties can be achieved in HPC.

Ramezanianpour, et. al., (1995) studied the effect of curing the compressive strength, resistance to chloride ion penetration and porosity of concretes incorporating GGBS, fly ash, and silica fume. They performed their investigations under four different curing regimes: moist curing, curing at room temperature after demoulding, curing at room temperature after two days of moist curing, and curing at 38°C and 65% relative humidity. Their results indicated that the reduction in the moist curing periods resulted in lower strength, higher porosity and more permeable concretes. The strength of concrete containing fly ash or GGBS appears to be more sensitive to poor curing than the control concrete. They also showed that the incorporation of GGBS or silica fume or high volumes of fly ash in the concrete mixes increased the resistance to chloride ion penetration and produced concrete with low permeability.

2.7. HARDENED CONCRETE

Irvani (1996) carried out a test program to develop information about the mechanical properties of high performance concrete of strength of 65 to 120
MPa (with or without silica fume). Results regarding the compressive strength gain with time, split tensile strength and modulus of rupture were also discussed. Sabir (1995) evaluated the compressive strength, tensile strength, and static modulus of elasticity of concrete containing various levels of silica fume with portland cement at two water curing temperatures. Although high-temperature curing ($50^\circ\text{C}$) accelerates the strength development at early ages, the 90 days strength does not appear to be influenced by temperature. The curing temperature does not affect the observed relationships between the tensile strength, the modulus of elasticity, and the compressive strength. Bayasi, et. al., (1993) investigated for silica fume-binder ratios from 1.0 to 4.0 and superplasticizer-binder ratios from 0.01 to 0.05.

Oluokun, et. al., (1991) investigated the relationship between concrete compressive strength and its splitting tensile strength, especially at early ages as well as examination of the applicability of some of the existing relations between these properties to concrete. Analysis of test results shows that the commonly accepted 0.5 power relationship between the compressive strength and splitting was found to be inaccurate at all ages. The specimen size and shape effects on the compressive strength of High Strength Concrete were investigated by Tokyay, et. al., (1997) on different sized cylinders having constant length-to-diameter ratio (l/d), different sized cubes and cylinders with various l/d. The compressive strength was found to be significantly affected by changing l/d.

Jayabalan, (2004) investigated the compressive strength of high performance concrete with fumed silica and reported that there were considerable increase in compressive strength of trial mixes in which cement was replaced by fumed silica at 5%, 7.5%, 10% and 15%. This result shows that, the use of fumed silica as an admixture gives ‘High Early Strength’, so as to attend the emergency repair works immediately. Mineral admixture such as
fumed silica is an ideal constituent for high performance concrete, as it has the inherent ability to contribute to continued strength development through their pozzolanic cementation reactivity.

2.7.1 Mortar

The compressive strength of silica fume cement paste and mortar were evaluated by Toutanji, et. al.,(1995) at various water-cementitious ratios. Five different water-cementitious ratios were used including 0.22, 0.25, 0.28, 0.31 and 0.34 and two contents of silica fume, 16% and 25% by weight of cement. The results show that the increase in compressive strength of mortar containing silica fume, as a partial replacement for cement, greatly contributes to strengthening the bond between the cement paste and aggregate. Buil, et. al., (1984) proved that the compressive strength of silica fume mortar was approximately twice higher at 28 days as compared to the reference mortar.

Khan et al, (2002) reported that the incorporation of silica fume content increase the early strength, but 8-12% silica fume yielded the optimum strength values. It has been reported that silica fume in concrete/mortar cause an efficient pozzolonic material which results in more impermeable pore structure when compared to plain cement paste. Sinan Caliskan (2003) has explained that 20% silica fume replacement with cement and addition of superplasticizer to the mortar produced a thinner interfacial zone than plain cement mortar.

2.8. DURABILITY OF CONCRETE

One of the principal reasons for the deterioration of many concrete structures stems from the fact that, in the past and even now, too much importance has been given to concrete strength when designing concrete structures and not enough to the environmental factors that the structure will have to face while performing its structural function. However, in recent years
a new attitude can be perceived towards durability in various national codes of Japan, Australia, Europe and Canada. (Rostam and Schissel (1993)

When looking at concrete from a durability point of view, it has been found that the high slumps achieved when using superplasticizers create a new type of heterogeneous zone along the forms or at top surface of the concrete. This zone has been known as the ‘concrete skin’ (Kreijger (1987), ‘outer skin’ (Bentur (2002) and Cohen (1991)), ‘concrete cover’ or simply as ‘covercrete’. Parrot (1992) recognized the importance of concrete skin (the outermost 5 to 10mm) from the durability point of view, in spite of the fact that the concrete skin does not have exactly the same composition and microstructure as the interior of the concrete, owing to the so-called ‘wall effect’. When a high performance concrete is plastified so that its slump is maintained, there is little risk of segregation, because the mix is quite rich and quite thixotropic. But it is observed that the wall effect is greatly increased when the slump increases.

The use of permeable forms seems to be an option very often used in Japan (Katayama, et. al.,(1991), Sugawara, et. al., (1993)) to improve the durability and aesthetics of concrete skin. Shannag, et. al., (2003) reported that HPC that contains silica fume and natural pozzolonas can provide a good balance between strength and durability. Austin and Robins (1997) found that the permeability of silica fume concrete reduces more rapidly during the first two months, due to the pore refining effect in that period. Malathy et al, (2003) have investigated the concert mixes containing 10 to 15% of cement replacement by silica fume and reported that the co-efficient of permeability was in the order of $6.5 \times 10^{-7}$ to $7.6 \times 10^{-7}$ cm/sec. Added to this, they have reported lower values of loss of weight in rebar for concrete mixes containing 5 to 15% replacement of cement by silica fume as compared to concrete mixes having only OPC as binder.
Natesan (2003) has investigated the concrete mixes containing 10 to 15% and 2.5 to 7.5% replacement of cement by fly ash and silica fume and reported that the co-efficient of permeability in the order of $2.72 \times 10^{-7}$ cm/sec. in addition to this, he has reported that the loss of weight of concrete (in acid resistance test) and loss of compressive strength (in sea water resistance test) were around 7.51% and 6.80% respectively for concrete mixes containing 10 to 15% and 2.5 to 7.5% replacement of cement by fly ash and silica fume respectively.

Hassan et al, (2000) in their report mentioned the beneficial effect of hot weather curing on condensed silica fume concrete was clearly reflected in the permeability and strength measurements. With 10% silica fume in concrete enhances the early ages as well as the long term properties of concrete. It reduces the permeability by 71% and 87% at 1 and 365 days respectively, when compared to normal concrete. Bharathkumar et al, (2001) have reported that the effect of mineral admixture on the strength of concrete varies significantly with its properties and replacement levels. They obtained water absorption of the order of 2.90 to 4.78% for concrete mixes containing cement replacement materials.

Gopalakrishnan et al, (2001) have investigated that the porosity and chloride ion-penetration values were in the order of 7.22 to 8.06% and 327 to 540 coulombs (ASTM equivalent) respectively, for concrete mixes containing 15 to 30% replacement of cement by fly ash. Rajamane et al, (2003) have found chloride ion penetrability values as 273 to 670 coulombs for concrete mixes containing 20 to 70% replacement of cement by GGBS. Ganesan et al, (2005) have examined the concrete mixes containing 5 to 35% of replacement of cement by rice husk ash and reported that the chloride ion penetrability values were 573 to 1154 coulombs respectively.
It is essential that every concrete structure should continue to perform its intended function, which is maintained by its required strength and serviceability during the expected life. It follows that concrete must be able to withstand the process of deterioration to which it can be expected to expose. Such a concrete is said to be durable. The durability of concrete structures incorporating silica fume is improved due to the significant decrease in permeability (Lessard, et. al., 1991 and Keck, 2001), high abrasion and erosion. It is also resistant to acid attack, because of lower CH content and decreased permeability of HPCs. C-S-H gel in hydrated cement is more resistant to acid attack than CH. Quantity of C-S-H gel in hydrated paste containing silica fume is increased due to the pozzolonic activity of silica fume. Therefore, HPC is extensively used in applications where the concrete is exposed to heavy abrasion, erosion, and wear such as, in dams spillways, stilling basins, offshore platform, roads and pavements.

Duming, et. al., (1991) and Torii, et. al., (1994) demonstrated that adding micro silica can increase the resistance of quality concrete to chemical attack by several aggressive chemical environments. The key reasons for the increase in resistance due to the addition of micro silica are the reduction in the permeability and the reduction or elimination of the free calcium hydroxide in concrete.

2.9. TOUGHNESS OF HIGH PERFORMANCE CONCRETE

Toughness, the energy absorption capacity can be computed from the area under the load-deflection curve obtained by conducting two point loading flexural test on beams. Many investigators (Bharathkumar et al, 1995), Balaguru, et. al., (1992), Joens, et. al., (2002), Mansur et al, (1985), Prasad, et. al., (2001), Ronald Zollo, (1997) have studied the effect of fiber types, fiber volume fraction, fiber length and aspect ratio, influence of testing conditions, influence of deflection measurement method, and age on the toughness
characteristics of fiber composites. Plain concrete has two major deficiencies; a low tensile strength and a low strain at fracture. Presence of numerous micro cracks reduces the tensile strength of concrete and toughness which is a measure of absolute energy capable of distinguishing among composites with different fiber types and fiber volume fractions. Increase in fiber content results in consistent increase in ductility and energy absorption capacity which in turn gives higher toughness indices.

Balaguru et al (1992), Gopalarathnam et al (1991), JCI (1983), JSCE (1984), Ramakrishnan et al (1989), Mitsuori Kawamura et al (1986) reported that the flexural strength of glass fiber reinforced concrete with silica fume has little effect on the durability. To properly evaluate the toughness (i.e. ductility and brittleness) of glass fiber reinforced concrete, two toughness indices are proposed. Both these toughness indices can be easily evaluated from flexural tests (Shah et al (1985)). Ramakrishnan et al (1989) investigated the behaviour of the steel fiber reinforced concrete with different fibers. Ramakrishnan (1997) reported that the addition of fibers significantly alters the concrete’s physical characteristics, especially toughness, ductility, and resistance to shrinkage cracking. Laboratory studies and field applications have demonstrated that advanced composites can reduce structural damage due to extreme loadings.
2.10 NEED FOR THE PRESENT STUDY:

From the foregoing discussions it was felt that the use of recycled concrete as aggregate for replacement of fine aggregate was not thought of by the investigators. Since there was an urgent need to cope with the short fall in the supply of fine aggregate this research was undertaken. Further, this was utilized for making High Performance Concrete which will satisfy three aspects concurrently namely disposal of wastes, obtaining durable High Strength Concrete with minimum cost.