CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

The concept of reinforcing the brittle matrix using fibres is not a new one. In Egypt, about 2000 years ago, straw was used for reinforcing the mud in the brick manufacturing process. Archeological evidences are available indicating the use of horsehair for reinforcing the plaster mortar by Romans since ancient times reported by Job Thomas (2002). In more recent times asbestos fibres have been used to reinforce cement products for about 100 years, cellulose fibres for at least 50 years and steel, polypropylene and glass fibres have been used for the same purpose for the past 30 years. In this chapter a brief review of literature related to the recent research work has been encompassed. All these reviews are scrupulously studied. Even though there are several literatures of research in the area of fibrous concrete but still much progress is possible in the area of fibrous concrete under thermoshock.

2.2 LITERATURE SURVEY

Romualdi and Batson (1963) published their classical paper on ‘Mechanics of crack arrest in concrete’. They concluded that application of linear elastic fracture mechanics to reinforced concrete indicates that the relatively low tensile strength of concrete is not inherent to the material and can be avoided with suitable reinforcement arrangement. At appropriate spacings, Incipient flaws are prevented from enlarging and propagating through out the tensile zone. In their another research (1963) it was concluded
that the first crack strength of concrete improves by mixing closely spaced continuous steel fibres in it. It was established that the increase in strength of concrete is inversely proportional to the square root of the wire spacing. Romualdi et al (1964) demonstrated that continuous steel wires could be replaced by randomly oriented small pieces of steel wires uniformly dispersed in the concrete matrix.

Balaguru and Ramakrishnan (1986) reported that under freeze and thaw cycling, behaviour of fibre reinforced concrete is similar to the behaviour of plain concrete. The addition of entrained air improves freeze-thaw durability. The moisture absorption is found to be less in fibre concrete than in plain concrete. It was also found that the modulus of rupture decreases with freeze-thaw cycling.

Gopalaratnam and shah (1986) discussed the effect of strain rate on the flexure behaviour of unreinforced matrix and three different fibre reinforced concrete mixes. It was concluded that FRC is more sensitive than plain matrix and showing improvement in flexural strengths of 79, 99 and 111 percent over respective static flexural strengths for the 0.5, 1.0 and 1.5 percent (fibre volume content) composites (aspect ratio of 62.5) at identical loading rates. Also they have developed modified charpy instrument to conduct impact tests and results obtained by them were found to vary with conventional impact tests.

Yamamoto et al (1986) examined the properties of superplasticised concrete under three different temperatures at 7, 20 and 35 degree Celsius. It was concluded that less dosage of superplasticiser was required at a lower temperature, which became quite significant in the temperature range below 20 degree Celsius. It was found that retarding types of superplasticiser was effective in reducing slump loss at higher temperature. Most of the properties of concrete were not significantly altered by superplasticising, but
considerable bleeding was observed especially when the setting time was delayed.

Antonio Nanni (1988) concluded that the splitting –tension test could be used to determine the tensile strength of fibre reinforced concrete commonly obtained with static flexural test. Also it was concluded that computation of first crack and ultimate crack is more convenient than that of flexural or direct tension test.

Balaguru and Ramakrishnan (1988) concluded that initial and final setting times of plain and fibre reinforced concretes were the same. Fibre concrete had lower slump & air- content and the rate of loss of these parameters with time was also higher. It was also observed that shrinkage of fibre concrete was slightly less but it underwent slightly more creep deformations. In the area of air void characteristics, the specific surface of air bubbles was lower for Fibre reinforced concrete.

Horiguchi, Saeki and Fujita (1988) concluded that the pullout strength increases with increase in the volume fraction of steel fibres. The maximum pull-out strength with 2.5 percent fibre reinforcement was found to be 1.6 times that of the unreinforced concrete. The magnitude of pullout strength is approximately the same as that of indirect shear strength but relatively larger than that of direct shear strength.

Banthia and Foy (1989) reported the effects of normal and sea water curing on the long term pull-out behavior of steel fibres embedded in cementitious matrices. The effects of silica fume addition and temperature of curing on the durability of a single fibre unit were also studied. It was found, based on a limited number of tests, that the marine curing of steel fibre concrete appears to be acceptable only at very low (less than 2° C) ambient temperatures. High temperatures promote early corrosion and lead to strength
reductions. The silica fume does not appear to enhance corrosion. This finding is relevant in the manufacture of fibres for marine applications.

Bentur (1989) reported that the use of alkali resistant glass fibres with silica fume was effective in improving durability performance of alkali resistant glass fibre reinforced cement composites (GFRC). Findings regarding silica fume replacement in the matrix and durability performance were also discussed. It was suggested that fibre usage eliminates the aging induced by microstructural effects, while the matrix modification reduces the influence of chemical attack.

Darmawan ludirdja et al (1989) developed a simple test to estimate the water permeability of concrete using gravity as the pressure head through a 12.5mm x 10mm disk at atmospheric pressure. It was suggested that the same apparatus could also be adapted for measuring ion diffusion.

Ezeldin and Balaguru (1989) reported the experimental results on the bond behaviour of normal and high-strength concretes made with and without fibres. The bond tests were conducted using a modified pullout test in which the concrete surrounding the bar was in uniform tension. Addition of silica fume results in higher bond strength but causes brittle bond failure. The slip (relative movement between the bar and the concrete) at maximum bond load increases with increase in fibre content.

Nanni and Johari (1989) conducted an experiment for pavement construction using steel fibre reinforced concrete (SFRC). The concrete matrix contained fly ash, either Class F (used as a filler) or Class C (used as a binder). He had presented compression and split tension results of laboratory cylinders and field cores reinforced with different types of steel fibre in various percentages. It was found that post-cracking characteristics were greatly enhanced by fibres beyond ultimate strength and also concluded that
toughness indexes can be obtained from stress-strain curves in split tension test.

Pailiere et al (1989) found experimentally that very high strength silica fume concretes undergo early cracking when deformation is restrained. This phenomenon, which occurs even when the concrete is protected against any evaporation, is attributed to autogenous shrinkage, because of its low water-cement ratio (0.26). An attempt was made to correct this weakness of the material by adding steel fibres. Two types of hooked fibres with ratios of length (in mm to diameter in hundredths of mm) of 30/60 and 50/50 were tested at a content of 0.8 percent by volume. For each type of fibre, the optimum sand-aggregate ratio giving maximum slump was determined together with the bending, compressive and tensile strengths of the material. It was concluded that the fibre concretes have an autogenous shrinkage lower than the reference concrete and undergo cracking at a later age under restrained deformation.

Zheng and Chung (1989) reported that carbon fibres are inert, medically safe, as strong as steel fibres and more chemically stable than glass fibres in an alkaline environment. By using short pitch-based carbon fibres together with a water reducing agent and an accelerating admixture, the compressive, tensile and flexural strengths of the carbon fibre reinforced cement mortar were found to increase by about 18-31%, 113-164% and 89-112%, respectively, compared to the corresponding plain cement concrete values. The ductility was also much improved. In addition, the electrical resistivity decreased to 0.1% of the plain cement concrete value.

Al-Tayyib, A-H. and Al-Zahrani (1990) reported the effects of addition of polypropylene fibre to concrete mix and adequate curing against the resistance of concrete surface skin subjected to cyclic wet/dry seawater exposure. Tests were carried out on 30 concrete slab specimens of dimensions
75 x 375 x 750 mm (3 multiplied by 15 multiplied by 30 in.), made with and without polypropylene fibers. Some specimens were cured under laboratory-controlled conditions and were subjected to the wet/dry cycles for 85 weeks, while others were cured under field conditions and were subjected to the same cycles for 50 weeks. The result was that the addition of polypropylene fibres effectively retards the deterioration process of the surface skin of the concrete specimens cured in hot weather environment.

Al-Tayyib and Al-Zahrani (1990) reported that adding polypropylene fibres (0.2% by volume of concrete) to concrete mixes enhances the properties of both fresh and hardened concretes. It was reported that polypropylene fibre reinforcement has no noticeable effect in retarding corrosion of reinforcing steel in concrete. It was concluded that results of the electrical resistivity, water absorption and permeability tests also do not show any significant improvement due to the inclusion of polypropylene fibres.

Barr et al (1990) described toughness measurements on polypropylene and steel fibre reinforced concrete mixes using both quasistatic tests and impact tests. Both types of test were carried out on identical notched fibrous beams subjected to three-point bending. While comparing the quasistatic and impact test results, it was reported that twice as much energy is absorbed in the impact tests as is absorbed in the quasistatic tests.

Ezeldin and Lowe (1991) presented an experimental program designed to study the mechanical properties of rapid-set materials reinforced with steel fibres. The primary variables of this study are: (a) rapid-set cementing materials; (b) fibre type; and (c) fibre content. Three commercially available rapid-set materials were investigated. The findings showed that steel fibres can be successfully mixed with rapid set materials up to a quantity of 75 lb/cu yd (45 kg / m³), and reported that the mechanical properties depend on the fibre shape, aspect ratio and its content.
Shah (1991) reported that many of the current applications of fibre reinforced concrete involve the use of fibres ranging around 1 % by volume of concrete. It was suggested that fibres do not influence the tensile strength of the matrix and that only after the matrix has cracked do the fibres contribute by bridging the cracks. Recently, it has been possible to incorporate relatively large volumes (ranging up to 15%) of steel, glass, and synthetic fibres in concrete. With such a large volume of fibres in concrete it was reported that the fibres may substantially increase the tensile strength of matrices.

Ahmed et al (1992) carried out experimental investigations to study the influence of high temperatures(100-600° C) on the residual compressive strength of concrete made from limestone. From this study it was reported that 7-day compressive strength of concrete increases upto 100 ° C. At this temperature range, young concrete showed a higher residual strength than old concrete. It was also reported that a decrease of 15% from its origional strength appeared at 150 ° C. It was also concluded that water-cooled specimens exhibited slightly higher values of compressive strength at temperatures above 200 ° C.

Balaguru (1992) discussed steel fibre reinforced rapid-setting concrete and reported that fibres have an excellent potential to improve the mechanical properties of rapid-setting materials and could be used for repairing works. The investigations indicated that the behavior of fibre-reinforced rapid-setting materials was similar to that of normal portland cement fibre-reinforced concrete.

Balaguru et al (1992) followed a new procedure to measure the deflections under flexural behaviour of steel fibre reinforced concrete (SRC). The variables investigated were fibre type, length and volume fraction, and matrix composition. The results indicate that fibre content in the range of 50
to 100 lb/cu yd (30 to 60 kg / m$^3$) of concrete provides excellent ductility for normal strength concrete. The fibre content has to be increased to about 150 lb/ cu yd (90 kg / m$^3$) for high strength concrete. It was reported that hooked-end fibre geometry provides better results than corrugated and deformed-end geometry. Fibre length in the range of 1.18 to 2.36 inch (30 to 60mm) does not have a significant effect on toughness for hooked-end fibres.

Ezeldin and Balaguru (1992) described the stress-strain behavior of fibre-reinforced concrete with compressive strength ranging from 5 ksi to 12 ksi (34.47 to 82.74 Mpa). The matrix consisted of concrete rather than mortar. The influence of fibre-reinforcing parameters on the peak stress, corresponding strain, secant modulus of elasticity and toughness of concrete were investigated. A simple equation was proposed to predict the complete stress-strain curve. It was found that the addition of hooked-end steel fibres to concrete, with or without silica fume, effectively increases the toughness of such concrete. The increase in silica-fume content renders the fibre-reinforced concrete more brittle as compared to non-silica-fume concrete.

Hackman et al (1992) discussed how SIMCON (slurry infiltrated mat concrete) is an improvement on SIFCON (slurry infiltrated fibre concrete) and also discussed SIMCON properties and tests. It was suggested that the SIMCON concept of reinforcement represents a significant improvement in the reinforcement efficiency in high density and high strength fibre reinforced concrete.

Saluja et al (1992) conducted the experiments on steel fibre concrete to determine compressive strength and concluded that steel fibres are effective in increasing compressive strength up to 1.0 percent fibre content, beyond which the increase is not much effective.
Taerwe (1992) discussed the results of loading tests on normal, medium, and high-strength concrete cylinders under axial compression. Special attention was paid to the descending part of the stress-strain curve. It was found that a very steep curve was obtained for high-strength concrete. It was reported that adding steel fibres to concrete mix had a beneficial effect on strain-softening behavior and significantly increases toughness, as measured by the area under the stress-strain curve.

Ashour and Wafa (1993) showed that eight high-strength concrete beams with different fibre contents and shear span-depth ratios were tested to study the influence of fibre addition at ultimate load, crack propagation, flexural rigidity and ductility. It was reported that the addition of steel fibres enhanced the strength and increased the ductility and flexural stiffness of the tested beams. A semi-empirical equation was proposed to estimate the effective moment of inertia of simply supported high-strength fibre reinforced concrete beams and concluded that the estimated deflections using this equation agree well with the experimental values. At ultimate conditions, the length of the plastic hinge developed was found to be proportional to the fibre content.

Balaguru and Dipsia (1993) investigated the workability and the behaviour under compression, splitting tension, flexure and shear strength of fibre reinforced high strength semilightweight concrete. Silica fume and high-range water-reducing admixtures were used to obtain the high strength. Study results showed that the silica fume can be successfully used to obtain high strength. The brittleness of silica fume concrete can be overcome by using fibres.

Banthia and Trottier (1994) investigated the Bond-slip characteristics for three deformed steel fibres bonded in concrete matrixes with different strengths. Fibres were aligned at 0, 15, 30, 45, and 60 degree
with respect to the loading direction and complete load-versus-slip curves were obtained. It was found that the bond-slip characteristics of fibres aligned with respect to the loading direction were significantly superior to those for inclined fibres.

Chakrabarti et al (1994) conducted the experiments on plain concrete under elevated temperature and concluded that increase in compressive strength for exposure to lower temperature range and decrease in compressive strength for exposure to higher temperature range. They also concluded that there is a recovery of compressive strength due to rehydration of concrete with time and recovery may be 80 percent of the initial strength.

Al-Oraimi, & Seibi (1995) conducted an experimental study on high strength concrete reinforced with glass fibres and natural fibres (palm tree leaves), both used at a relatively low volume fraction. Compressive, splitting, three-point bending and impact test had been conducted to characterise reinforced concrete materials and the results were analysed statistically. It was investigated that natural fibres enhanced the mechanical properties & impact resistance of concrete and exhibit comparable response to the glass fibres. A finite element model using ANSYS was employed to study the flexural behaviour of fibre reinforced concrete and concluded that both experimental and numerical results were in good agreement.

Hughes and Al-Dafiry (1995) conducted tests on both, beam segments and reinforced concrete beams to ascertain the extent to which the local effects of hard impacts which affects the total energy absorbed. The total energy absorbed by a reinforced concrete beam when struck by a hard impactor depends in part on the local energy absorbed both in the contact zone and by the impactor. They suggested that the energy absorption on initial indentation of the concrete in the contact area is shown to be very small for either plain or fibre concrete. Thus the practical advantage of fibres in the
shattered zone is that the fibrous concrete can still hold together under large deformations. Also they outlined a simplified approach for designing reinforced concrete beams for impact load by quantifying the energy absorption from the moment-rotation characteristics and since the total energy absorbed by an impacted beam depends essentially upon the load-deformation behaviour, this approach can also be used as a basis to assess the advantages of using fibre reinforcement in conjunction with conventional bar reinforcement.

Balasubramanian et al (1996) concluded that addition of fibres, even in a small quantity, considerably improves the impact resistance of concrete. Among trough shaped, crimped shaped and straight fibres. It was found crimped fibres were found more effective in improving impact strength and at 0.5% volume of crimped fibres the impact strength was trebled as the age of concrete increased from 28 days to 90 days.

Hugo Armelin and Nemkumar Banthia (1997) developed a model on simple mechanics to predict the flexural toughness of steel fibre reinforced concrete SFRC from the pull out of single fibre at different inclination and compressive strength of matrix as a parameter and developed model was in good agreement with experimental results. Investigation was concluded that the pull-out force of individual fibres can be related to overall toughness performance of steel fibre reinforced concrete under flexural loading if an average fibre pull-out force approach is used to take into account the influence of fibre inclination, embedment, embedment length and fibre density distribution.

Bhal & Jain (1999) conducted experiments to study the behaviour of concrete in compressive strength when it is subjected to elevated temperature and discusses some of the important factors affecting compressive strength. It was concluded that elevated temperature has significant effect on compressive
strength in the hot and cold states and there is a definite loss of compressive strength of concrete when subjected to high temperature.

Chakrabarti and Arvind Kumar Jain (1999) reviewed the work of various researchers and suggested that there is loss in strength and other properties of concrete and steel at elevated temperature.

Nataraja et al (1999) reported the variation in impact resistance of steel fibre-reinforced concrete and plain concrete determined from a drop weight test by statistical approach. It was reported that the goodness-of-fit test indicated poor fitness of the impact resistance and suggested that more number of specimen required to reliable measure of the impact strength for goodness of fit.

Dale P. Bentz. (2000) conducted experiments to study the failure of high performance concrete during exposure of fire. A three dimensional micro structural model for fibre reinforced concrete was developed to examine the spalling phenomena of high performance concrete. With reference to experimental study and modal examining it was suggested that 20mm fibre provide superior performance than 10mm fibre.

Krishnamoorthy et al (2000) discussed the investigation to find the influence of corrosion of steel fibres on the strength and toughness characteristics of steel fibres reinforced concrete. The specimen were subjected to accelerated corrosion by continuous wetting in salt solution and subsequent drying and found that there was no corrosion of steel fibres embedded in concrete even after exposure to 250 cycles of corrosion. During flexural test, the test result on SFRC specimen which were exposed to accelerated corrosion does not affect flexural strength and toughness characteristic of SFRC even though brown stains were noticed.
Zongjin Li and Chung-Kong Chau (2000) aimed to develop efficient concrete permeability test scheme which is based on the principle of water penetration test. They suggested that by utilizing an autoclave, at least 18 concrete samples can be evaluated simultaneously under the same operating conditions. In addition, a new vacuum coating method, that offers an excellent bonding between concrete surface and resin coating compound, was introduced to eliminate any boundary leakage. They concluded that the proposed test scheme increases the testing efficiency of permeability measurements and also improves the consistency of results of the water permeability test on concrete.

Bairagi and Modhera (2001) developed a very simple method for obtaining shear strength of concretes and the proposed technique could be applied on concrete both plain and FRC subjected to the various time-lag and temperature cycles. It was suggested that in the absence of any standard procedure, this method in which preparation of the specimens and testing operation could be made the simplest and at same time ensuring reliable and consistent results could be achieved.

Nataraja et al (2001) conducted the experiments and concluded that addition of steel fibre in concrete increases the splitting tensile strength significantly. Splitting tensile strength was 0.67 times the flexural tensile strength for crimped fibres for compressive strength up to 50 MPa. Splitting tensile strength was 0.09 times the compressive strength for crimped fibres for compressive strength up to 50 MPa.

Ramakrishnan et al (2001) concluded that it was feasible to make concrete beams reinforced with basalt composite rebars. However the bond between the bar and the concrete should be increased in order to increase load carrying capacity of the beams. Finally it was concluded that the basalt rebars
had a great potential of replacing the steel bars if some minor deficiencies were rectified.

Singh and Dhinrendra Singhal (2001) concluded that addition of steel fibres into concrete resulted in significant decrease in permeability due to arrest of plastic shrinkage cracks. The decrease in permeability with addition of fibre continued with increasing weight fraction of fibres but the effect was more pronounced at 1.0% weight fraction. The fibres were found to be more effective in reducing the permeability than in compressive as well as tensile strength.

Ziad Bayasi and Henning Kaiser (2001) investigated crack width behaviour of steel fibre reinforced concrete. It was conducted the test on samples with different fibre content, ranging from 0 to 2 percentage. It was concluded that an increased amount of fibres improves the crack arresting capacity of concrete and increases the closure stress at constant crack width. The energy absorption capacity of concrete was improved with an increase of fibre content.

Giaccio and Zerbino (2002) presented the Marsh cone results of a study on cement pastes wherein different types of superplasticisers were combined with Portland cements of different finess, blended cements with natural pozalonas or silica fumes. Sulphonated naphthalene, sulphonated melamine and vinyl copolymer based superplasticisers and conventional water-reducing admixtures were used. It was concluded that dosage required for fluidity were similar for both Sulphonated naphthalene , sulphonated melamine based superplasticiser but the flow times were higher for sulphonated melamine based superplasticiser.

Job Thomas (2002) concluded that balling of fibres were present when the fibre content was 1% and this ultimately reduce the strength.
characteristic of the fibre concrete. It was also suggested that bridging of fibres was effective across the micro cracks up to a fibre content of 0.75% and which enable the composite to take up a higher load than the ordinary concrete.

John S Lawler et al (2002) concluded that the use of reinforcing fibres was found effective to produce a significant reduction in water permeability through a modification of crack topography. This was direct implications for improving durability because many deterioration mechanisms of cement-based materials by the ingress of water.

Samir Surlaker (2002) presented about the major advantage of the new generation superplasticiser. Most of the new generation superplasticiser are from acrylic polymer family. It was suggested that this is a special advantage to the ready mixed concrete industry as it mix new the generation superplasticiser in the batching plant itself and can be assured of virtual no loss of slump with respect to time. It is easy to get 3-5 hours workability with the new generation superplasticiser.

Suresh et al (2002) concluded that higher the strength of concrete higher the value for reduction in compressive strength of concrete when subjected to sustained elevated temperature. It was suggested that the reduction in residual flexural strength was higher as compared to residual compressive strength for the same temperature and duration.

Ziad Bayasi and Mubarak Al Dhaher (2002) concluded exposure to elevated temperature causes the decrease in ultimate flexural strength of polypropylene fibre concrete and this decrease becomes more pronounced as temperature increases and the length of duration increases. Prolonged exposure to 125 degree Celsius causes similar trends of reduction in ultimate strength of plain and polypropylene fibre concrete with 0.2% volume.
Also it was concluded that post peak strength of polypropylene fibre concrete was decreased at elevated temperature.

Ashok K. Jain and Vasan (2003) conducted the experiments and concluded that flexural strength of SFRC is very sensitive to the quality of fine and coarse aggregate and balling of fibres. It was concluded that the maximum increase in flexural strength of the SFRC over that of PCC was 70%. Sometimes there was no increase at all in the flexural strength of the SFRC over that of the PCC depending upon the method of mixing of steel fibres, aspect ratio of fibres, volume of fibres and water-cement ratio.

Balaguru P and Najm H (2004) reported the test results that SFRC with fibre volume fraction upto 3.75% could be achieved in the field using mortar matrix and mixture proportions. Various mortar mixtures include cement type II and Type V, sand, condensed silica fume and high range water reducing admixtures and three types fibres like hooked steel fibres, straight steel fibres, and polypropylene fibres. It was reported that all mixtures tested in this study were able to attain 3% or more volume fraction of steel fibres without loss of flow and workability. Flexural strengths were obtained from 12 to 24 MPa. Compressive strength was between 12.6 to 17 MPa. It was concluded that FRC with hooked steel fibres had highest toughness compared with other fibres.

Senthilkumar and Natesan (2004) conducted tests to investigate the effectiveness of synthetic fibres in controlling restrained plastic shrinkage cracking in different concrete mixes subjected to various environmental conditions. It was concluded that synthetic fibres were effective in reducing the extent of shrinkage cracking area and crack widths and higher the rate of free water surface evaporation, higher the crack area in all the concrete mixes. It was also added in their conclusion that higher the cement-aggregate ratio higher the crack area or maximum crack width in all drying environments.
Tike et al (2004) reported that the superplasticisers may be used within the specified dosage limits stipulated by the manufacturer. It is advisable to initially get the superplasticiser tested in the laboratory for its effectiveness for the type of use, initial slump, and slump loss with time elapsed till the finishing operation is over for the actual field conditions. Thereafter every batch of superplasticiser should be evaluated for variations from batch to batch.

Alexander et al (2005) attempted to sketch a way forward for performance –based durability specifications, using the so-called ‘Durability Index’ approach. This involves obtaining reliable measures of physical and engineering parameters (Durability Indexes) which relate to transport mechanisms (permeation,scorption, ionic diffusion) that govern reinforced concrete deterioration. These measures need to be obtained on actual ‘as built’ structures, so as to characterise in-situ performance. It was suggested finally that Durabilty Index values, once ‘matrixed’ to account for effects of binder type, exposure environment, concrete cover and service in life can then be used to specify limiting criteria to be achieved in construction.

Antoine et al (2005) concluded that the higher the volume fraction of fibres, the better the control of plastic shrinkage cracking. For all practical purposes, at 0.4% volume of fibre content will totally eliminate plastic shrinkage cracking.

Nataraja et al (2005) conducted an experimental study on reproportioned plain and fibre reinforced concrete mixtures. This is to economise the cement content. In addition, the impact resistance of these reproportined plain concrete and Steel fibre reinforced concrete was studied at 7 days and 28 days and was observed that the SFRC has developed significant impact resistance even for a small addition of steel fibres.
Ganesan et al (2006) conducted experiments to study the effect of steel fibres on the durability parameters of self compacting concrete (SCC) such as permeability, water absorption, abrasion resistance, resistance to marine as well as sulphate attack. The variables considered were aspect ratio (0, 15, 25 and 35) and volume fraction (0, 0.25 , 0.5 and 0.75 percent) of steel fibres. The water-cement ratio of 0.36 by weight and a blend of cement, fly ash and silica fume were used. A total of 244 specimens were cast and tested for this study. It was observed that the coefficient of permeability and wear of Steel fibre reinforced self compacting concrete (SFRSCC) were lower than the corresponding moderate strength concrete. Under the marine and sulphate attack, the losses in mass of concrete and compressive strength of cubes were found to be negligible. It was observed that SFRSCC resists these attacks within tolerable limits and the optimum dosage of fibres for better performance was found to be 0.5 percent.

Lau and Anson (2006) reported that after being subjected to different elevated heating temperatures, ranging between 105 °C and 1200 °C, the compressive strength, flexural strength, elastic modulus and porosity of concrete reinforced with 1% steel fibre (SFRC) and changes of colour to the heated concrete have been investigated. The results showed a loss of concrete strength at increased temperature.

Malathy and Subramanian (2006) concluded that addition of mineral admixtures improve the impact strength of concrete significantly. The use of glass fibres greatly increases the impact resistance of concrete and can be useful under impact loading conditions. Also, it is worthy to note that the impact resistance of the concrete could be greatly enhanced by the addition of fibres in pozzolanic concrete.

Raul L Zerbino et al (2006) concluded that during compression failures, fibres restrain crack propagation leading to an increase in post-peak
nonlinearity of the high strength concrete. It was concluded that for higher strength matrices, there was a notable improvement in the behaviour of concrete when high carbon steel fibres were employed.

Srinivasa Rao et al (2006) reported that the thermal cycles have adverse effect on the compressive strength of ordinary concrete. The compressive strength of ordinary concrete for M20 and M30 decreased by about 13% at 50°C after 28 thermal cycles. The resistance to adverse effect of thermo cycles is more for fly ash concrete when compared to ordinary concrete.

Srinivasa Rao et al (2006) reported that concrete structures are exposed to temperature variations mainly due to solar radiation. As reported in literature, concrete containing 100 percent ordinary portland cement (OPC) exhibited a steady decline in residual compressive concrete strength when subjected to thermal cycles. The results revealed that concrete containing fly ash was more effective in resisting the effect of thermal cycles than concrete containing OPC and concluded that the compressive strength of ordinary concrete for M20 and M30 decreased by about 25% at 100°C after 28 thermal cycles and However for fly ash concrete the compressive strength was found to increase by 12% after 28 thermal cycles at 100°C.

Erhan Güneyisi et al (2007) investigated experimentally effects of cement type, curing condition and testing age on the chloride permeability of concrete. Chloride permeability of concrete was determined through rapid chloride penetration test (RCPT). Experimental test results indicated that cement type, W/C ratio, curing condition, and testing age were very effective on the chloride permeability of concretes. The concretes subjected to wet curing procedure resulted in higher resistance to chloride permeability in comparison to uncontrolled and controlled curing conditions. Empirical model was developed by using Neural Network to have a high prediction
capability of the chloride permeability of concretes. It was found that the model developed by using NN seems to have a high prediction capability of the chloride permeability of concretes in terms of water–cement ratio, aggregate–cement ratio, superplasticiser–cement ratio, cement type, curing condition, and testing age.

Omer Arioz (2007) presented that the effects of elevated temperatures on the physical and mechanical properties of various concrete mixtures prepared by ordinary Portland cement, crushed limestone and river sand. Test samples were subjected to elevated temperatures ranging from 200 to 1200 °C. After exposure, weight losses were determined and then compressive strength test was conducted. Test results indicated that weight of the specimen significantly reduced with an increase in temperature. This reduction was very sharp beyond 800 °C. The effects of water/cement (w/c) ratio and type of aggregate on losses in weight were not found to be significant. The results also revealed that the relative strength of concrete decreased as the exposure temperature increased.

Mohammadi et al (2008) presented that the results of an investigation conducted to study the impact resistance of steel fibre reinforced concrete containing fibre of mixed aspect ratio. The drop weight type impact tests were conducted on the test specimens and the number of blows of the hammer required to induce first visible crack and ultimate failure of the specimen were recorded. The results are presented in terms of number of blows required as well as impact energy at first crack and ultimate failure. It has been observed that concrete containing 100% long fibres at 2.0% volume fraction gave the best performance under impact loading.
2.3 **SUMMARY OF REPORTS**

1. It is observed that most fibres were used to study the performance of concrete with steel fibres and polypropylene fibres.

2. Comparison of cost analysis of concrete with different types of fibres were not reported to suit use in construction site for Civil Engineers, Builders and public use.

3. No research was found in concrete with AR Glass fibre, polyester fibre and Steel fibre subjected to thermoshock effect for strength and durability evaluation for fibrous concrete.

4. It has been found that no research has been conducted on Impact strength of fibrous concrete subjected to thermoshock effect.

5. It was found that there was no report about the relation between cylinder compressive strength and cube compressive strength for fibrous concrete.

2.4 **NEED OF PRESENT INVESTIGATION**

It is witnessed from the summary of reports that there is an urgent emerge on need of testing fibre reinforced concrete before and after thermoshock. Four decades ago, construction chemicals or fibres were rarely used as admixture in concrete due to the lack of awareness and confidence among builders, practicing Engineers, contractors and the public. But as of now, the sustained efforts of researchers all over the world to innovate and incorporate unmatched excellence in construction chemicals and fibres have led momentous developments in improving mechanical and durability properties of cement concrete. In India, keeping this in mind, several companies are competing with each other in the manufacture of these products. The only literature available on these products are the manufacturers’ brochures. In the absence of norms for fibres, the
manufacturers or suppliers advertise their products as “Anti Crack” & “Steelcrete” material capable of taking care of every eventuality. The specific norms or standards for comparison of their products and applications are missing. Moreover the information pertaining to the acceptance criteria for each product is by and large not readily available.

Moreover, the performance of fibres of different types in concrete which is subjected to thermoshock needs to be investigated. When concrete under fire or subjected to elevated temperature, there are two possible mechanisms for failure of concrete like spalling of concrete, progressive cracks formation that leads disruption of concrete. One possible mechanism reported by Hertz (2005) is during fire or at elevated temperature thermal incompatibility between aggregates and cement paste. During exposure to fire the aggregate expands and cement paste contract due to loss of moisture and leads to the generation of drying shrinkage cracks. And another possible mechanism reported by Dale P. Bentz (2000) and Khoury (2002) for spalling of concrete is due to the built up of very high pore pressure with in the concrete. This is a result of the liquid-vapour transition of the capillary pore water as well as that bound in the cement paste component of concrete. A larger portion of water is released between 100 and 250 degree Celsius and at this temperature C-S-H gel formation begins to degrade. If this water vapor can not escape from the concrete significant pressure will develop and may eventually cause spalling of concrete. At this juncture, it becomes greater necessary for investigating the performance of different fibres for enhancing the residual properties of concrete after being subjected to high temperature.

At this present scenario, a detailed investigation has to be made on concrete with different individual fibres to improve the strength and durability before and after thermoshock. Therefore it becomes necessary to make a comprehensive study on the performance of these fibres and assess the extent of their usefulness to the Civil Engineer.