2. LITERATURE SURVEY

Batson and et al [1] have reported the results of flexural fatigue testing of steel fiber reinforced concrete beams. Several sizes of steel fibers were used as reinforcement in concentrations of 2.00 and 2.98 percent by volume of concrete. Statistical analysis of the test data indicated fatigue strengths of 73 and 84 percent of the first crack static flexure strength at 2 million cycles of complete reversal and non-reversal of loading, respectively and has concluded followings.

1. Fatigue strengths of 74 and 83 percent of the first crack static flexure strength at 2 million cycles of complete reversal and non-reversal of loading were obtained for a steel fiber content by volume of 2.98 percent.
2. The post fatigue static flexure strength was greater than the prefatigue static flexure strength.
3. Beams failed by the pulling out of the fibers, not breaking of the fibers.

Henager [2] has investigated the factors affecting rebound has shown that the most effective measures to reduce material rebound are to reduce the air pressure (air velocity or amount of air at the nozzle), to use higher percentages of fines, to use shorter fibers, to predampen (if necessary) to get the right moisture content, and to shoot the mix at the wettest stable consistency.

Colin, Johnston [3] have studied, the performance of concretes containing 1 % by volume (79 kg/m\(^3\)) of fibers with and without entrained air. Using ASTM Method C666, Procedure A which ensures full saturation, he has compared the specimens without entrained air (air content 2%) reached a relative dynamic modulus of 60 % (the test end point) in about 40 cycles, while those with a 6.5 % air content maintained a relative dynamic modulus in excess of 95 % to the total of 300 cycles employed in the test method.

It is clear that SFRC has passed from the realm of a new relatively untried and unproven material to one which has achieved considerable success in a variety of applications simply because, despite its recognized limitations, it offers both technical and economic advantages over the conventional alternatives.

ACI Committee 544[4] , has suggested their majority of experience with steel fibers in the United States has been with mixes using normal weight aggregate and Portland cement as the binder. The methods of mixing, placing, consolidating, and finishing for
steel fiber reinforced concrete have been developed to a reasonable degree, particularly for pavements. The greater difficulty in handling steel fiber reinforced concrete requires more deliberate planning and workmanship than established concrete construction procedures. Present mechanical methods of producing and handling regular concrete may or may not be appropriate for fiber reinforced concrete depending on the many mix parameters involved. The volume and type of fibers selected determine the maximum aggregate size and volume of paste. With these factors known, the techniques of good concrete proportioning can be applied to obtain workable and economical mixes.

Mark and et al [5] have proposed about the stiffness of steel fiber reinforced concrete and its sensitivity to fiber content and damaging load. An experimental program has been implemented to measure Young’s modulus of plain and SFRC beam samples, and then to damage these samples in a controlled manner. Successive damage and modulus measurements lead to the correlation of damage with degeneration of Young’s modulus of SFRC materials. The following relationships are obtained: 1. Stiffness of undamaged SFRC versus fiber content, and 2. Degeneration of SFRC stiffness with damaging load. This assessment of stiffness has both applied and theoretical relevance’s that are discussed. They have reported that, Young’s modulus for a fiber content of 1.8 percent was as much as 20 percent less than the E of plain concrete. Each of the samples was subjected to a vibration test to determine its natural frequency, from which a value of E was determined.

Ravindrarajah and Tam[6], have studied on strength of (partially) reinforced beams with fibers in the bottom layer only is about 25 % more than that for fully reinforced beams. They have suggested that, the presence of fibers in the compression zone does not significantly improve the strength in beam. A delay in casting between the plain concrete and fiber concrete layers does not significantly change the ultimate strength of partially fiber reinforced concrete beams. For the volume fractions of steel fibers incorporated, an improvement of about 25 % was noted at 7 days. Regression analysis indicated a good correlation coefficient of 0.92) between the ultimate strength and the bottom fiber layer depth it appears from these results that up to 0.375 of the beam depth, the presence of equal fiber concrete layer thickness at the top of the beam has a secondary influence on the load carrying capacity of the beam. In relation to the fully fiber reinforced beams 2-layer beams showed improvements of 19m 26 and 31 % for fiber contents of 0.25, 0.50 and 0.75 % respectively. However, 3-layer beams at these fiber contents showed nearly equal flexural strength to the corresponding fully fiber reinforced beams. The strength
gain characteristics of 2 layer beams is due to the increase in fiber content of the bottom fiber concrete layer.

Rostasy and Sprenger [7] have studied the mechanical behavior of SFRC at low temperature and after temperature cycles in comparison to plain concrete. Variables, besides the testing temperature, were:

- Type of cement, Portland cement pc and Portland blast furnace cement pfc according to DIN 1164 of the strength class 35 MPa.
- Type of steel fiber.
- Volume fraction of fiber; 0, 1 percent and 2 percent by volume.
- Number of low temperature cycles.

The specimens were stored under water until testing because water-saturated concrete exhibits eventual changes of the mechanical behavior due to low temperature in the most marked fashion. The mix proportion of the concrete was cement aggregate: water = 1:5.3 : 0.54. The tests proved that by addition of steel fibers the loss of compressive and tensile strength of concrete due to repeated thermal cycles can be markedly reduced. This behavior was very beneficial with respect to the service ability and imperviousness of a prestressed concrete outer tank which may suffer severe thermal shocks due to leakage.

Naaman and Gopalratnam [8] have investigated in the experimental programme three volume fractions of fibers (1 %, 2 % and 3 %), three fiber aspect ratios (47,62 and 100, two mortar mixes and four strain rates of loading ranging from 0.5 x 10^-5 to 1.2 strains per second. It has been found that depending on the fiber reinforcing parameters the energy absorbed by the conforming parameters the energy absorbed by the composite at static loading rates can be one to two orders of magnitude higher than that of the unreinforced matrix. Moreover, up to a three-fold increase is observed in the modulus of rupture and the energy absorbed by the composite when the strain rate increases from 0.5 x 10^-5 to 1.2 strain per second.

Puurkiss [9] have reported on steel fiber reinforced concretes at elevated temperature. The residual compressive strength, flexural strength, dynamic modulus and ultrasonic pulse velocity were measured on specimens with no fibers and with 0.75 % plain or crimped fibers and 1.5 % plain fibers over a temperature range of 300-800^\circ C. In general the results show that below 600^\circ C fiber reinforced concrete performs better than plain concrete, although the type of fiber and percentage of fibers seem only to have a secondary effect.
The residual compressive strength of fiber reinforced concrete is sensibly independent of fiber type and fiber content, and below 600°C is considerably higher than that for plain concrete.

There is a similar trend in evidence for the tensile strength which, however, continues over the whole temperature range examined.

There is little evidence of there being any beneficial effect when pulse velocity or Young’s modulus (dynamic modulus) is considered.

There is for all the mixes tested, a reasonable correlation between loss in pulse velocity and loss in flexural strength or cube strength.

John and Shah [10] studied the concrete with compressive strength up to 140 MPa. It has been shown that one cannot use the same empirical relationships between compressive strength and other properties such as splitting tensile strength, flexural strength, shear strength, and bond strength as those currently being used, and different relationships for high-strength concrete have been proposed. In this paper, a fracture-mechanics-based theoretical model is used to predict various experimentally observed trends for high-strength concrete. The size independent fracture parameters needed for this model can be derived from a single test. The proposed fracture-mechanics-based model satisfactorily predicts the variation of uniaxial tensile strength, split cylinder strength, and modulus of rupture with compressive strength up to 110 MPa. The relatively linear of high-strength concrete is also predicted by the model.

Bentur and Goldman [11] have studied the physical properties of high strength silica fume concretes and their sensitivity to curing procedures were evaluated and compared with reference portland cement concretes, having either the same concrete content as the silica fume concrete or the same water to cementations materials ratio. The marked increase in the strength of the silica fume concrete over the two reference concretes, which was observed even at one day, was not accompanied by liberation of excessive heat. The shrinkage of the silica fume concretes was much lower due to the smaller weight loss on drying. The effects of poor curing procedures on the strength, and the skin properties, were found to be equally detrimental in the reference and in the silica fume concretes.
There is a growing interest in the use of high strength concretes with their superior mechanical properties and improved durability. One of the most attractive means of producing such concretes is by the incorporation of silica fume and super plasticizer in the mix, which permits high strength, high workability concretes using moderate cement contents (Sellevold and ilsen 1987; ACI Committee 226 1987). Most of the studies of such systems are based on evaluation of the strength and permeability (or diffusibility) of such systems when cured in ideal laboratory conditions. However, for many applications other characteristics of the concretes should be considered at the same time, including the rate of heat liberation and the drying shrinkage of the hardened concrete. The generally higher cementitious materials content in such concretes, compared to normal strength concretes, can involve changes in such concretes, compared to normal strength concretes, can involve changes in heat liberation and shrinkage which may not necessarily be favorable.

Since many of the high strength concretes are formulated by using pozzolans, and the silica fume might be included in this category, there is always the concern to what extent are these concretes more sensitive to the water curing procedures than concretes prepared with Portland cement only. This is particularly important in hot-dry climatic conditions, where the concrete is dried more readily, thus perhaps eliminating the moisture that is needed for the progress of the pozzolanic reaction which can continue to occur beyond the initial few days of the water curing period. In evaluating the effect of curing, one should consider the overall strength of the concrete, as well as the properties of the concrete skin (i.e. outer layer), which protects the steel reinforcement.

- The presence of SF resulted in a marked increase in strength, especially at 28 days, but also at 1 day. This, however, was not accompanied by excessive heat liberations: Beyond 2 days the heat evolved in the SF concrete was similar to that of the reference concrete having the same cement content (reference I), and much smaller than that of the second reference concrete (reference II) with a higher cement content but with a water to cementitious material ratio similar to that of the SF concrete. During the first 24 hours, the heat liberated by the SF concrete was in between that of the two reference concretes.
- The calorimetric measurements suggest an accelerating effect of the SF on the reaction of the Portland cement, and this may account for the relatively high strength achieved at one day, although the pozzolanic reaction is probably not very effective at this stage.
The presence of SF reduced the shrinkage strains considerably, and this was accounted for by the much lower rate of weight loss in this system, due probably to its much finer pore structure. However, when comparison is made on the basis of equal weight loss, the shrinkage strains in the SF concrete were greater than the reference concretes.

The effects of poor curing procedures on the strength and skin properties of concretes were found to be equally detrimental in the reference and in the SF concretes.

Arnon Bentur [12] have studied the treatments with silica fume slurry were applied to improve the durability of alkali resistant (AR) glass fiber reinforced cement composites (GFRC). Two treatments were studied: fiber treatment obtained by immersion of the reinforcing strand in the slurry, prior to their incorporation in the composite, and matrix modification of the matrix by replacing with 10% silica fume. Fiber treatment alone was found to be extremely effective, leading 50% or more toughness retention after 5 to 9 months of accelerated aging. Additional modification of the matrix led to better performance, with the toughness retention exceeding 50%. Matrix modification alone did not yield any significant improvement. The effects of the silica fume treatments were discussed in terms of the microstructural and chemical aging mechanisms.

Glass fiber reinforced cement (GFRC) was shown to be a valuable material for construction of thin sheet building components. The advantages of this material are exhibited in the various production processes developed, which enable to make simple or complex shaped components, and in the improved tensile strength and toughness of the material itself which enables the transportation, handling and erection of the sheet components. The major advantage of this composite is its tendency to lose part of its tensile (flexural) strength and most of its toughness (i.e. embrittlement) when exposed to outdoor weathering, especially in humid conditions. This process takes place even with alkali-resistant (AR) glass fibers, although at a slow rate. As a result, the application of this composite is restricted to non-structural or semi structural components, and special design procedures and precautions must be considered to accommodate its tendency for embrittlement (Prestressed Concrete Institute 1987).

Youjiang Wang and Stannley Backer [13] have determined methods currently used to evaluate the toughness of fiber reinforced concrete (FRC) are reviewed. Parameters
representing the fracture energy determined from the area under the load displacement curve obtained from conventional laboratory tests are discussed. An improved toughness parameter is proposed based on the secant compliance (the displacement/load ratio), rather than judging by load or displacement alone as by conventional methods. The new parameter is shown to represent the toughness properties of FRC in a more consistent manner than other similar methods when applied to a wide range of idealised load-displacement curves. However like other toughness parameters determined from the area under the load-displacement curve, its use should be limited to comparisons among results obtained under the same test conditions.

Mansuur and Ong [14] have proposed modifications to the softened truss model incorporate rationally the effects of inclusion of short and discrete steel fibers in concrete on the behavior and strength of deep beams. The modified theory gives very good predictions of the strength as well as the entire load-deformation response for the present test data. Therefore, it provides a rational basis for developing suitable design methods for reinforced fiber concrete deep beams.

- A reduction in the shear span-depth ratio increases both the diagonal cracking and ultimate shear strengths of reinforced fiber concrete beams.
- Addition of discrete steel fiber in the concrete mix provides better crack control and enhances the strength and deformation characteristics of deep beams containing conventional reinforcement.
- The proposed modeling of the stress-strain relationships of fiber concrete for the softened truss model accurately predicts not only of the ultimate shear strength but also the load-deformation response for the entire range of loading.

Raina and Mansour [15] have tested plain and steel fiber reinforced concrete cubes under uniaxial and biaxial stresses. Ninety-six 3 in. (76 mm) cubical specimens were used in the testing program. Three principal compression stress ratios, two different steel fibers, and three fiber concentrations were the main variables. Static compressive strengths, stress-strain relationships, volume change, fiber aspect ratio l/d, fiber volume concentration V_f, failure modes, and crack arrest mechanism were examined.

The experimental results showed that uniaxial compressive strength of steel fiber reinforced concrete increased, decrease, or did not change (depending on fiber type and concentration) in comparison to plain concrete. The highest increase in uniaxial strength was about 22 percent in the case of 1.18 in (30 mm) fiber length (l/d=60) at 1.5 percent concentration. For biaxial compression, steel fiber concrete showed higher compressive
strength than plain concrete for all cases. The increase was 78 percent in the case of 1.08 in. fiber length (l/d=60) at 1.5 percent fiber volume concentration at a stress ratio S=σ/σ0 equal to one. The addition of steel fibers to plain concrete changed the failure mode from the usual tensile splitting type failure to shear type failure.

Johnston and Zemp [16] have investigated the performance of steel fiber reinforced concrete under flexural fatigue loading is examined in terms of fiber content (0.5 to 1.5 percent by volume), fiber aspect ratio (477 to 100), and fiber type (four types). Data from 194 fatigue tests and 135 complementary static loading tests are presented both as S-N relationships, with the maximum stress expressed as a percentage of the strength under static loading, and as relationships between actual stress and number of loading cycles.

The S-N relationships depend primarily on fiber content and aspect ratio. Fiber type is secondary in importance. The 100,000 cycle endurance limits are 84 to 89 percent of the first-crack strength under static loading for the better combinations of fiber type and amount characterized by at least 1.0 volume of fibers of aspect ratio 70 or greater. The corresponding limits drop to 75 to 80 percent for the less effective combinations characterized by fiber amounts of 1.0 percent or less and aspect ratios of 47 to 54.

The relationships between actual stress and number of cycles depend primarily on fiber content. Aspect ratio and type are secondary in importance, especially when differences in water cement ration (w/e) and water-cement + fly ash w/(c+f) are taken into account. The best performance, a 100,000 cycle endurance limit of 6.9 MPa, is obtained with 1.5 percent by volume of 75 aspect ratio cold-drawn wire fibers in a concrete with a w/(c+f) of 0.49. For 0.5 percent of the same fibers, the 100,000 cycle limit is only 5.2 MPa despite a lower w/(c+f) of 0.39.

Niema [17] have studied the effect of steel fibers on the behavior and strength of reinforced concrete beams under shear. Nine fiber reinforced beams and one plain reinforced concrete beam were tested by two-point loading. The fiber content ranged from 0.4 to 1 percent, and the aspect ratio of the fibers was between 60 and 120. Improvement of first crack load and ultimate load over that of plan concrete was noted. The first crack strength ratio of fibrous and plain beams was a function of fiber spacing. The ultimate strength of fibrous beams under shear was much higher than that of the plain concrete beam, depending on the energy absorbed in deboning and stretching the fibers, which is directly proportional to the fiber volume content and aspect ratio.

The research reported in this paper shows the effect of steel fibers in improving the first crack load and ultimate load of reinforced concrete beams under shear. It is the
first time that strain has been measured in both the tension and shear reinforcement of fibrous reinforced concrete beams. The influence of the fibers on these strains was clearly shown. The paper presents useful data on shear strength of steel fiber reinforced concrete beams, particularly for test data separating aspect ratio and fiber volume percentage.

- Steel fibers affect the shear behavior of reinforced concrete beams.
- The first crack strength is clearly increased with an increase in aspect ratio.
- The volume percentages of fiber had a strong influence on the ultimate shear load.
- The toughness and ductility are improved with increasing volume percentages and aspect ratio of fibers.

Antonio Nanni [18] have presented in his investigation to determine the load-deformation response of fiber reinforce concrete (ASTM C-1018) and split tension (ASTM C-496) tests with the objective of studying the correspondence between the FRC tensile properties obtained with the two methods. This comparison is desirable since split tension performed on cores or cylinders could be preferable to the more common flexure test with regard to ease of specimen collection or fabrication, and testing. In this study, a total of 17 fiber types from the United States, Europe, and Japan are used at two or more different volume contents. In terms of pseudoductility, it is found that the flexural test effectively differentiates between fiber content and type. On the contrary, the instrumented split-tension test, with deformation measured along the horizontal diameter (perpendicular to the load plane), shows a flat post cracking response that is almost independent of fiber content and type. In the latter test, fracture propagates in a controlled and stable fashion for almost all the FRC specimens tested as a result of the improved pullout strength of the fiber.

The addition of fibers lends pseudoductility to a cementitious matrix by providing a mechanism of crack arrest. The flexural test has been recognized as the standard method for determining FRC performance and measuring toughness properties. Because of some drawbacks in this testing procedure, it was hoped that the split-tension test would be an acceptable complement or substitute, particularly for testing field-collected specimens. The two tests procedures correspond with regard to first crack strength, i.e., split tension consistently lower than flexure, but the split tension test highly overestimates the pseudoductility of FRC as measured under flexure and does not differentiate between fiber types nor contents. This is because fibers bridging the primary crack are confined by
a matrix subjected to high compression, and the tensile stress field rapidly decreases away from the cracked zone.

Based on experimental results obtained using 17 fiber types, including steel and synthetics, it is concluded that the split tension test cannot substitute for the standard flexural test in determining the post crack performance of FRC. The split tension test remains a good method to monitor tensile properties of FRC prior to cracking.

Sameer Ezeldin[19] used steel fiber-reinforced concrete in structural applications, the complete stress strain behavior of the material in compression is needed. This paper presents the experimental stress strain behavior of fiber reinforced concrete with compressive strength ranging from 5 ksi to 12 ksi to 12 ksi (35 MPa to 85 MPa). Three fiber volume fractions of 50 ib/cu yd, 75 ib/cu yd, and 100 lb/cu yd (30 kg/m3, 45 jkg/m3, and 60 kg/m3) and three aspect ratios of 60, 75 and 100 are investigated. The influence of the fiber reinforcing parameters on the peak stress, corresponding strain, the secant modulus of elasticity, the toughness of concrete, and the curve shape are reported. A simple equation is proposed to predict the complete stress strain curve. Addition of steel fibers to concrete with or without silica fume effectively increases the toughness of such concrete. A marginal increase in the compressive strength, the strain corresponding to peak stress, and the secant modulus of elasticity is also obtained. The increase of silica fume content renders the fiber reinforced concrete more brittle than non-silica-fume concrete. The equation proposed to generate the complete stress strain curve for non-silica-fume fiber-reinforced concrete provides a good correlation between predicted and experimental results.

Wafa and Samir [20] have studied the effect of hooked end steel fiber reinforcement on the mechanical properties of high strength fiber reinforced concrete. Fiber content ranges from 0 to 1.5 percent by volume and the concrete matrix compressive strength is about 94.0 MPa. The influence of fiber content on the compressive strength, modulus of rupture, toughness, and splitting tensile strength is presented. Addition of 1.5 percent by volume of hooked end steel fibers resulted in a small increase (4.6 percent) in the compression strength while the modulus of rupture and the splitting tensile strength increase by 67.0 and 159.8 percent, respectively.

Based on the test results of 504 high strength concrete specimens using hooked steel fiber reinforcement with an aspect ratios of 75, the following conclusions were drawn:
No real workability problem was encountered when up to 1.5 percent hooked end steel fibers were used in the mixes. However, HSFRC mixes required more mixing and finishing time than mixes without fibers.

High strength concrete is a brittle material and fails suddenly. Addition of steel fibers in discrete forms into high strength concrete changes its brittle mode of failure into a more ductile one and improves the concrete ductility, its post cracking load carrying capacity and its toughness. Fiber addition results in more closely spaced cracks, reduces the crack width, bridges cracks and thus improves resistance to deformation.

The addition of 1.5 percent by volume of hooked end steel fibers results in a small increase of about 4.6 percent, in the compressive strength, and results in an increase of 67.0 percent in the modulus of rupture and 159.8 percent increase in the splitting tensile strength compared with the unreinforced matrix.

The tensile strength as measured by the modulus of rupture for high strength concrete is closely estimated by the equation.

Samir and Wafa [21] has studied the addition of fibers in high strength fiber reinforced concrete beams has a significant effect on the flexural rigidity and, hence, on beam deflections in the working range. This paper evaluates the effect of steel fibers in improving flexural behavior in general and flexural rigidity in particular of simply supported HSFRC beams subjected to two point loads.

Hooked ends mild carbon steel fibers with average length of 60 mm (2.36 in) nominal diameter of 0.8 mm (0.03 in.) aspect ratio of 75, and yield strength of 1100 MPa (159,500 psi) were used. A super plasticizer was used and enough mixing time was allowed to produce uniform mixing of concrete without any segregation.

Mindess, Chen, and Morgan [22] has determined the first crack strength and flexural toughness of steel fiber reinforced concrete specimens containing different volumes of steel fibers (0 to 1.5 %) using the procedures outlined in ASTM c1018, and the ASTM toughness indices were calculated.

It was concluded that the toughness indices depended both upon how the first crack deflection was determined, and upon how deflections were measured. This indicates that the ASTM toughness indices are strongly influenced by the particular test procedures and methods of analysis used. Seven groups of specimens were cast, with fiber contents (by volume) of 0, 0.5, 0.75, 1.0 and 1.5 % at the used, 0.35, 0.50 and 0.55.
For these mixes, the super maintain comparable work abilities. The fibers used were hooked end fibers 30 mm long and 0.5 mm in diameter.

Tan, Paramasivam, and Tan, [23] have investigated about the inclusion of steel fibers enhances the cracking strength of reinforced concrete beams and inhibits crack propagation after cracking resulting in higher post cracking stiffness and, hence, better deflection control in this study, steel fiber reinforced concrete beams were subjected to sustained loads of various levels. The results indicated that the addition of steel fibers leads to smaller instantaneous and long term deflections. A simple method following the ACI approach is developed and is shown to predict both the instantaneous and long term deflections of SFRC beams in the present study and those available in the literature with good accuracy.

Jean-Francois Trottier [24] have investigated four deformed commercial fibers with widely different geometries in steel fiber reinforced concrete. Three matrices with compressive strengths of 42, 52 and 85 MPa were reinforced with fibers at a dosage rate of 40 kg/m3. Compressive and flexural strengths were measured along with the elastic moduli. The focus of the study, however, was to measure and characterize the toughness improvements in the basic matrices due to the addition of various fibers. To this end, flexural load deflection curves were analyzed in accordance with the ASTM and Japan Society of Civil Engineers (JSCE) standard methods and also using a proposed analysis scheme. The paper points out the limitations of the current techniques of toughness characterization and identifies this as an area with immediate research needs. For the fibers and the matrices investigated, a strong influence of both fiber geometry and matrix strength on the toughness characteristics of fiber reinforced concrete was observed. End deformed fibers were in general, found to perform superior to those deformed through-out the length.

Lianrong Chen and et al [25] have studied the ASTM toughness indices are not independent of specimen dimensions unless the specimens are geometrically similar.

- The JSCE toughness factor is roughly independent of specimen size for geometrically similar specimens, although this parameter is derived from an absolute approach.
- The measured toughness parameters decreased with an increase in the span-to-depth ratio of the specimens.
All the toughness parameters were significantly affected by the width of the beam, even if both depth and span were unchanged. The toughness increased with an increase in width.

Tan and Paramasivam [26] have suggested the punching Shear Strength of Steel Fiber Reinforced Concrete the following conclusions have been drawn.

The load deflection curve of SFRC slabs under a concentrated load exhibits four distinct regions:

1. The Initial elastic uncracked region
2. The crack development region
3. The post yielding region
4. The post peak region.

The critical perimeter for punching shear failure in SFRC slabs forms at a distance of about 4.5 times effective depth from the perimeter of the loading platen, with the shear plane inclined at 20° – 60° to the plane of the slab. Punching shear failure in SFRC slabs is preceded by yielding of steel reinforcement and is accompanied by cracks mainly in the radial direction and partly in the circumferential direction. An increase in the volume fraction of steel fibers, slab thickness, compressive strength of fiber concrete, or the loaded area generally leads to an increase in the cracking load, yield load, ultimate load, and ductility of SFRC slabs. The punching shear strength of SFRC slabs in the present study was predicted with reasonable accuracy using the BS-CP110 equation for reinforced concrete.

Nemkumar and Trottier [27] have proposed an alternate technique. Four fiber geometries and three concrete compressive strengths are investigated and their toughness is characterized using both existing methods and the proposed technique.

Tan and Murugappan [28] have investigated steel fibers as shear reinforcement in partially prestressed beams. The inclusion of steel fibers was found to enhance the ultimate shear strength of partially prestressed concrete beams.

The ultimate strength of partially prestressed SFC beams increases with a decrease in the shear span to effective depth ratio. It does not vary much with a different partial prestressing ratio.
The web cracking load increases with an increase in steel fiber content, a decrease in shear span to effective depth ratio or an increase in partial prestressing ratio.

Stirrups may be replaced by an equivalent amount of steel fibers without significantly affecting the behavior and strength in shear of partially prestressed concrete beams.

The proposed equation for the contribution of steel fibers to shear carrying capacity leads to conservative estimates of the ultimate shear strength of partially prestressed concrete beams when used in conjunction with ACI or BS provisions for shear design.

Taylor, Lydon and Barr [29] have studied the fiber reinforced concretes which required nominal mean 28 day cube strengths of 40, 60, 80, 100 and 120 N/mm². A standard 42.5 N Portland cement (BS 12) was used, which had a C3S/C2S ratio of about 6.1, with a marine dredged sand and either a crushed limestone or a gravel of 10 mm maximum particle size for strengths of 80 N/mm² and greater.

Mix proportions were chosen to produce fresh concrete of high workability and suitable for inclusion of a reasonable volume of fibers. Values of slump were typically 150 = 50 mm but did not adequately reflect the workability and stability of the range of concretes used. Cement contents varied from about 340 to 510 kg/m³, with water/cement ratios of 0.24-0.56. There seemed to be a practical limit to the 28 day cube strength of about 115 N/mm² with the limestone and 100 N/mm² with the gravel with the materials used. Good correlations were found between cube strength and three forms of indirect tensile strength.

Wee and et al [30] have studied the stress-strain relationship of high strength concrete in compression. Strain at peak stress increases with an increase in concrete strength. The high strength concrete produced using crushed granite as coarse aggregate, it is found that as long as the compressive strength remains the same, the method of achieving it by varying a combination of factors, like the water/binder ratio, type of mineral admixture, percentage replacement, and age at testing, has no effect on the shape of the stress strain curve, except for the use of hi-fi as cement replacing admixture.

Nemkumar Banthia and et al [31] have studied that Impact Resistance of Steel Fiber Concrete. Concrete may be subjected to rapidly applied impact loads generating very high stress rates. Given that concrete is a brittle, stress rate sensitive material, a special consideration of these characteristics in the design of structures subjected to impact loads.
is essential. Unfortunately, our understanding of the behavior of concrete under the high stress rates associated with impact is far from adequate and continued research is clearly needed. A simple instrumented impact machine designed to test concrete in uniaxial tension is described here. Impact data for normal strength, medium strength, high strength, and fiber reinforced concrete is presented.

- This paper proposes a simple technique of testing concrete and its fiber reinforced composites under impact. It is demonstrated that with the proposed technique, meaningful material properties under impact loading can be obtained that can then be useful in designing structures subjected to impact loads.
- Impact data for plain and fiber reinforced cement based materials indicate that these materials are sensitive to stress rate. In general, they are both stronger and tougher under impact loading compared to static loading.
- Fiber reinforcement is effective in improving fracture energy absorption under impact. The improvements are however, dependent on fiber type and geometry, and the improvements are not as pronounced as observed under static conditions. The strength of the matrix has a decisive effect in that, under impact, the higher the strength of the matrix, the less effective the fibers in improving fracture energy absorption.

Standard Test Method for Fundamental Transverse, Longitudinal, and Torsional Resonant Frequencies of Concrete Specimens, ASTM International,[32] have proposed the methods of measurement of the fundamental transverse, longitudinal, and torsional resonant frequencies of concrete prisms, and cylinders for the purpose of calculating dynamic Young’s modulus of elasticity, the dynamic modulus of rigidity (sometimes designated as “the modulus of elasticity in shear”), and dynamic poisson’s ratio.

- This test method is intended primarily for detecting significant changes in the dynamic modulus of elasticity of laboratory or field test specimens that are undergoing exposure to weathering or other types of potentially deteriorating influences.
- The value of the dynamic modulus of elasticity obtained by this test method will, in general, be greater than the static modulus of elasticity obtained by using Test Method C469. The difference depends, in part, on the strength level of the concrete.
The conditions of manufacture, the moisture content, and other characteristics of the test specimens (see section on Test Specimens) materially influence the results obtained.

Different computed values for the dynamic modulus of elasticity may result from widely different resonant frequencies of specimens of different sizes and shapes of the same concrete. Therefore, it is not advisable to compare results from specimens of different sizes or shapes.

Spadea and Bencardino [33] have studied the behavior of composite concrete sections reinforced with conventional steel bars and steel fibers, and subjected to flexural cyclic loading beyond the yield point of steel bars, is analyzed by means of a mechanical model. The stress strain relationships for the concrete, for the steel fiber, and for the steel bars are assumed to be piecewise linear. These constitutive laws are used to obtain the primary moment curvature relationship of the section for a monotonically increasing load up to failure. On this basic curve, the successive stiffness, degradation is created as a function of stress and strain levels reached in the section at each load cycle. Strain hardening of steel and the combined effect of confinement ensure by the stirrups and met al fibers are compared with experimental results available in literature. Subsequently, the model is applied to study concrete sections reinforced with steel bars and steel fibers, subjected to a flexural cycle, with identical mechanical and geometrical specifications to the reinforced concrete sections. The equality of the maximum curvature reached to each load cycle for both kinds of sections is imposed, and comparisons are drawn in terms of energy dissipation.

Mansur and et al [34] have investigated the complete stress strain curves generated experimentally for high strength plain and fiber concretes by transverse ties. The test parameters include tie spacing, concrete core area, and casting direction of specimens. Test results indicate that the initial tangent modulus and initial Poisson’s ratio of the concrete are not affected by confinement. However, confinements enhance both the peak stress and strain at peak stress. Vertically cast confined fiber concrete exhibits large strain at peak stress and has higher post peak ductility compared to the corresponding horizontally cast specimen. Vertically cast confined no fiber concrete also has larger strain at peak stress, but ductility is hardly improved over horizontally cast specimens. Based on test data, an analytical model is proposed to generate the complete stress strain
curves of high strength concrete confined by lateral ties. The proposed model has been found to agree well with the stress strain curves generated experimentally.

Claise and et al [35] have studied the absorption characteristics and sorptivity of cover concrete obtained by the initial surface absorption test (ISAT), the concrete absorption test (CAT), and the sorptivity test have been studied and compared. Two types of concrete, namely ordinary Portland cement (OPC) control and low water concrete (LWC) of grade 35 have been tested. The laboratory work has shown close agreement between the ISAT and sorption results but the CAT yields higher results. Ann analytical model has been developed based on the mechanisms of capillary suction and pressure driven flow. In this model water entering concrete during the test is assumed to be concentrated in a well-defined volume. This volume is fully saturated and is separated from the surrounding concrete by a wetting front at which capillary suction occurs. By applying the physical equations for capillary suction pressures and permeability the experimental results are explained in terms of the basic properties of the concrete. The model gives good agreement with the experimental results. Surface absorption tests on concrete samples have been modeled using the basic equations for capillary suction and permeability and the results show good agreement with experimental data. The higher results obtained from the CAT experiment relative to ISAT have been explained.

Poh [36] have presented the general stress strain equation that expresses stress explicitly in terms of strain in a single continuous curve. It allows features such as linear elastic range, upper yield peak, plastic plateau, and smooth strain hardening portion to be included. Any of these feature can be excluded if desired. The shape of the curve described by the equation is identical, with positive and negative strains. The equation has been fitted to experimental data to represent the stress strain behavior of material and is therefore useful for describing experimental results in a brief format. Comparison with experimental results shows that the equation can closely fit the stress strain curves steel at various temperatures at temperatures where distinct yield peaks and plastic plateaus exit; as well as at temperatures where the stress strain curves are smooth. Therefore, the equation can be suitable extended to accurately model the temperature dependent behavior of steel.

A general equation for representing the stress strain relationship in single continuous expression has been presented. The equation is very versatile and it allows features as the linear elastic range, upper yield peak, plastic plateau, and smooth strain
hardening particularly useful when the equation is extended to reflect the marked changes in the shape of the stress strain curve as temperature changes, as in the case of steel at various temperatures. Comparison of the expression with experimental results shows that the equation can closely fit the stress strain results for steel at all temperatures.

Agnes Nagy [37] have investigated the modulus of elasticity of concrete at very early ages by means of a nondestructive method. The method covers measurements of the dynamic resonance frequency on concrete prisms with fast Fourier transform (FFT) analyzer. At a known resonance frequency the dynamic E-modulus and the damping coefficient can be calculated. Based entirely on the dynamic test results a simple empirical formula is suggested for prediction of the static modulus of elasticity. Application of the prediction formula for two concrete mixtures showed consistency and good agreement with the static test results. The advantage of the dynamic procedure is that the method enables measurement of progressive changes in the test results relative to the static method.

Siddik Sener[38] have studied the failure of cylinders under the uniaxial compression. Cylinders of three different diameters (37, 5, 75 and 150 mm) were tested. For all the cylinders, the height to diameter ratio was $h/d = 2$. The cylinders were made of micro concrete with maximum aggregate size 4.76 mm and the compressive strength ($f'_c$) of concrete was found between 34 and 48 MPa depending on the sized of specimens. The concrete mix proportions of water cement : aggregate : silica fume : super plasticizer were 0.3:1:4:0:1:0.08. The results reveal the existence of a significant size effect that can be approximately described by the size effect law previously proposed by Bazant. The experiments indicate that larger specimens tend to fail in a more brittle manner, while smaller specimens tend to fail in a less brittle or more plastic failure.

Naaman [39] have investigated several properties of HSFRC for the fresh mixture, the air content, inverted slump test, temperature, and unit weight; for the hardened composite, the compressive, bending, and tensile properties. Optimum mixtures that satisfied the minimum compressive strength criterion, and showed excellent values of modulus of rupture, toughness indices in bending, and split tensile behavior, were selected for fatigue testing. The experimental program included a total of 24 fiber reinforced concrete flexural specimens, ten of which were control specimens tested under static flexural loading, and the remaining 14 specimens have been tested under fatigue loading. Two mixes containing 2 % of hooked steel fibers were selected. For each mix, three different target load ranges were applied: 10-70 %, 10-80 % and 10-90 % of the ultimate flexural
capacity, as obtained from the corresponding control static test with fibers. A typical relation between maximum fatigue stress and number of cycles to failure was derived, suggesting a fatigue endurance limit of the order of 65 % even if specimens are in a cracked.

Jenn-ChuanChem and et al [40] have presented the results of an experimental study on the effects of temperature and humidity on deformations of steel fiber reinforced concrete (SFRC). The programme consisted of creep and shrinkage test. Creep tests were performed in a moist room (called as basic creep), drying room (drying creep and total deformation), and high temperature room (high temperature creep). Shrinkage specimens were exposed to 50 % RH in the drying room. The influence of loading ages on creep and exposure ages on shrinkage of specimens was investigated. Steel fibers were used at volume fractions ranging from 0 to 2 % by volume of mix. Test results indicate that the basic creep shrinkage and total deformation measured are all lower for SFRC than for companion plain concrete. The temperature activation effect is reduced for concrete made with higher fiber content.

Tat -Senglok and et al [41] have studied the constitutive model for steel fiber reinforced (SFR) concrete is proposed, in which the tensile behavior incorporates a bilinear strain softening feature. Composite material properties (f, Vf, L/d, Td) fiber volume concentration (Vf) fiber aspect ratio (L/d) and fiber concrete matrix bond stress (Td) are used to define the model. The model may also exhibit strain hardening characteristic depending on the magnitude of the variables. Based on the constitutive mode, the full history of the flexural moment curvature relationship for SFR concrete is calculated. Predicted curves are superimposed onto and compared with published experimental data. The results show good overall agreement; the post cracking softening and post cracking strengthening response were predicted. In order to facilitate the rapid assessment of the ultimate flexural behavior of SFR concrete, a secondary tensile model is derived from the proposed model. A strain softening parameter (α) is defined for the secondary model and used to evaluate the performance and efficiency of steel fiber reinforcement. The predictive technique using this parameter can be applied to SFR concrete containing various concrete strengths, types of fibers, and fiber concentrations.

Phan and et al [42] have provided systematic comparison of results of high temperature test on NSC and HSC specimens, conducted by various researchers, to examine the effect of high temperature exposure to the mechanical properties on concretes with different original compressive strengths.
NijjadFattuhi [43] have studied the prediction of the moment curvature relationship for steel fiber reinforced (SFR) concrete. The prediction is based on a tensile stress strain model where the softening branch is modeled by a bilinear stress strain relationship. Model predicted moment curvature relationships has found in an overall good agreement with published experimental data. Emphasis is given on role of fiber and fiber/matrix interfacial properties in influencing the flexural behavior of SFR concrete. From a materials engineering perspective, this point is of considerable relevance.

Barros and et al [44] have presented the results of tests performed on specimens and structural elements made of steel fiber reinforced concrete (SFRC). Fiber content of the concrete ranged from 0 to 60 kg/m3. Using the results of the uniaxial compression tests performed under displacement control condition, a stress strain relationship for fiber concrete in compression was derived. Three point bending tests on notched beams were carried out to simulate the post cracking behavior and to evaluate the fracture energy. Based on the constitutive relationships derived from the experiments, a layered model for the analysis of steel fiber reinforced concrete cross sections has been developed. The model performance and the benefits of fiber reinforcement on thin slabs reinforced with steel bars were assessed by carrying out test on slab strips.

Campione and et al [45] has evaluated the optimum combination of fibers and steel spirals to obtain the same level of fracture energy dissipation as that obtained by using only a high volume percentage of spiral steel, which is generally used in real structures. The experimental program consisted of testing 100 x 200 mm concrete cylinders under compression at two different strength levels: normal (48 MPa) and high strength (75MPa), reinforced with different percentages Vf(1.5, 2, and 3 percent) and lengths Lf (705, 20 and 30 mm) of high strength carbon fibers with an equivalent diameter 0.78 mm. These were then repeated with the addition of spiral reinforcement. Øs =5 mm diameter, with different pitches s (25 and 50 mm). The objective was to improve the seismic resistance of structures by an optimum combination of fibers and steel spirals, to obtain the same level of fracture energy dissipation as that obtained by using only a high volume percentage of spiral steel. There should also be an improvement in the maximum strain of the concrete, corresponding to the failure of the spirals.

Zhang Dong and et al [46] have studied the fracture behaviors of normal strength concrete are well understood after about 20 years of worldwide research. As the strength of concrete increases, its fracture properties become more important, because on the one
hand high strength concrete is more often used in complicated structures that are vulnerable to damage by external loads, and on the other hand concrete becomes more brittle as its strength increases. And as the strength of concrete increases, the internal damage pattern changes greatly, so it is not proper to transfer knowledge of the fracture properties of NSC directly to HSC. The test results of fracture properties of HSC as well as NSC are presented and compared with the empirical formulas of CEF FIP Model Code 1990 (MC90) in the paper. It is found that (1) tensile strength and elastic modulus of HSC match MC90’s formulas, as well as NSC and (2) fracture energy and characteristic length of HSC are lower than predictions from MC90’s formulas, while those of NSC are slightly higher than predictions from MC90’s formulas.

Maria de Lurdes and et al [47] has reported on the compressive strength of steel fiber high strength concrete (SFHSC) subjected to high temperatures. The concrete specimens were preheated to different temperature levels, and the existence of a cooling phase was also considered as a variable. During the heating phase the compressive strength of the SFHSC has shown to be more affected by high temperatures than normal strength concrete without fibers. In general, a gain was registered in the compressive strength of the specimens after cooling. Stainless steel fibers with the commercial designation of Dramix ZP30/.50, with properties indicating an aspect ratio (length/diameter) of 60, a density of 7,800 kg/m3, a tensile strength of 1,150 MPa and a Young’s Modulus of 200 GPa were used in a proportion of 0.8 volume percent (or 2.5 mass percent – 62.5 kg/m³).

The steel fibers added to the fresh concrete and mixed to ensure uniform dispersion.

Julie Rapoport and et al [48] has studied the relationship between permeability and crack width in cracked, steel fiber reinforced concrete. In addition, it inspects the influence of steel fiber reinforcement on concrete permeability. The feedback controlled splitting tension test (also known as the Brazilian test) is used to induce cracks of up to 500 µm.

Kholmyansky, has suggested [49] The method of synthesis which includes three simplifications: (1) independence of the influence of longitudinal and transverse components of the fiber; (2) simplified dependence between the bond stresses and the conventional mutual displacements and (3) simplified dependence between the transverse component of the fiber stress and the fiber transverse displacement.

Padmarajaiah and Ramaswami, [50] have presented in their study the results of an experimental and analytical comparison of the flexural behavior of a high strength concrete specimen (no conventional reinforcement) with average plain concrete cube strength of nearly 65 MPa and containing trough shape steel fibers. Trough shape steel
fibers with a volume fraction ranging from 0 to 1.5 % and having a constant aspect ratio of 80 have been used in this study. Increased toughness and a more ductile stress strain response were observed with an increase in fiber content, when the fibers were distributed over the full/partial depth of the beam cross section. Empirical and mechanistic relations have also been proposed in this study to establish the load deflection behavior of high strength FRC.

Harajli and Karam[51], suggested an experimental study undertaken to evaluate the characteristics of the local bond stress slip response of reinforcing bars (RBs) embedded in plain and steel fiber reinforced concrete (FRC). It has been found that fiber reinforcement increases substantially the splitting bond strength and leads to a significant improvement in the ductility of bond failure in comparison to plain unconfined concrete. The increases in the local bond strength were 26 and 33 % for $v_0$ of 1 and 2 % respectively.

Lionello Bortoloti [52], studied a theoretical contribution to understanding the failure behavior of concrete under pullout load in provided in addition to existing solutions on the subject. In view of this, the results obtained in the punching theory will be applied to the case of pullout failure. In order to explain the previously mentioned increase in ultimate load, a process of hardening in tension of concrete will be hypothesized as being due to the small size of the reaction ring of the pullout test apparatus. The assumption is made in order to provide reliable expressions to predict the concrete strength from the pullout load. In order to obtain analogous expressions to confirm the theoretical results, an appropriate statistical mathematical procedure will then be performed on experimental data found in the literature.

Giovannnni Pascale and et al.[53] deals with nondestructive testing of high strength concrete. An experimental program was carried out, involving both destructive and nondestructive methods applied to different concrete mixtures, with cube strength varying from 30 up to 150 MPa “Relationships were derived for pulse velocity rebound hammer, putout, probe penetration micro coring, and combined met5hods. The results show good behavior for some methods, like pulse velocity rebound hammer, and combined SonReb methods. The relationship for the various methods has been compared in terms of dimensionless sensitivity, for different strength levels.

Bischoff [54], investigated the post cracking response of reinforced concrete tension members made with both plain and steel fiber reinforced concrete (SFRC). Loading was either monotonic or cyclic, and shrinkage effects are included in analysis of the member
response. Tension stiffening values are used to determine the average tensile response of concrete after cracking an expression is developed to predict this smeared behavior as a material property for cracked SFRC, as well as to estimate crack spacing. Specimens with steel fibers exhibited increased tension stiffening and smaller crack spacing, which both contributed to a reduction in crack widths. The post cracking tensile strength of fiber concrete at the cracks behavior for conventionally reinforced SFRC. The uniaxial strength of SFRC immediately after cracking governs serviceability behavior, while the post cracking strength at larger deformations governs strength design and is responsible for tension stiffening after yield of the reinforcement. Cyclic loading did not have a significant effect on tension stiffening or crack width control for the specimens tested.

Kodur and Sultan [55], obtained the data from their experimental studies which are used to develop simple relationships expressing thermal properties as a function of temperatures for various types of HSC. These relationships can be used as input to computer programs (Sullivan et al. 1993; Kodur and Lie 1996) to determine the behavior of HSC structural members at high temperatures.

Chidiac and et al. [56] examined the experimental of three parameters - mix design, formwork, and consolidation - on the quality of the surface of high w/c concrete. The fresh concrete is characterized using its rheological properties in particular, its yield stress and plastic viscosity. Pulse velocity, pull-off strength, and compressive strength were measured to evaluate the quality and the mechanical properties of the hardened concrete. The durability of the hardened concrete was evaluated by measuring its surface transport properties namely its air permeability and sorptivity. The results show that it is possible to correlate the rheological properties of fresh concrete to the mechanical and permeation properties of the hardened concrete.

Singh, and Kaushik, [57] have studied on the fatigue strength of steel fiber reinforced concrete (SFRC). An experimental programme has been conducted to obtain the fatigue lives of SFRC at various stress levels and stress ratio. Sixty seven SFRC beam specimens of size 100 100 100 mm were tested under four point flexural fatigue loading. Fifty four static flexural tests were also conducted to determine the static flexural strength of SFRC prior to fatigue testing. The specimens incorporated 1.5 % volume fraction corrugated steel fibers of size 0:6 2:0 30 mm. Concept of equivalent fatigue life, reported for plain concrete in literature, is applied to SFRC to incorporate the effects of stress level S, stress ratio R and survival probability L into the fatigue equation. The results indicate
that the statistical distribution of equivalent fatigue life of SFRC is in agreement with the two parameter Weibull distribution.

Balaguru and Najm, [58] has investigated on high performance fiber reinforced concrete (FRC) was performed that showed high performance FRC with fiber volume fractions up to 3.75% of 30 mm long holed steel fibers can be achieved using conventional mixing and appropriate matrix compositions. Based on this investigation, the optimum fibers content was dependent on mixture design constituents, fiber types, and mixing procedure. The mixtures were successfully produced in a ready mix plant. Flexural strengths obtained varied from 12 to 24 MPa. Compressive strengths varied from 74 to 100 MPa and splitting tensile strengths were from 12.6 to 17 MPa. The flexural toughness of mixtures achieved in this study was two to three times higher than those of conventional FRC.

Poon and et al, [60] have presented the effects of elevated temperatures on the compressive strength stress strain relationship (stiffness) and energy absorption capacities (toughness) of concretes. The results showed that after exposure to 600 and 800°C, the concrete mixes retained, respectively, 45% and 23% of their compressive strength, on average. The results also show that after the concrete was exposed to the elevated temperatures, the loss of stiffness was much quicker than the loss in compressive strength, but the loss of energy absorption capacity was relatively slower. The steel fiber reinforced concretes also showed the highest energy absorption capacity after the high temperature exposure although they suffered a quick loss of this capacity. Song, Hwang, [58] has investigated the strength improving potentials of HSFRC containing 0.5% to 1.0%, comparison with the plain high strength counterpart, and established models predicting the behavior of HSFRC under compression, splitting tension, and flexure.

Padmarajaiah and Ramaswamy, [61] determined the influence of trough shaped steel fibers in altering the flexural strength at first crack and ultimate, the load deflection and moment curvature characteristics, ductility and energy absorption capacity of the beams. The magnitude of the priestess, volume fraction of the fibers ranging from 0% to 1.5% and the location of fibers were the variables in the test program. Empirical relationships for the ultimate strength, first crack load level, load versus deflection and moment versus curvature as a function of fiber content have been proposed by making use of force equilibrium and compatibility considerations.

Bayramov and et al, [62] optimized the fracture parameters of steel fiber reinforced concrete to obtain a more ductile behavior than that of plain concrete. The effects of the
aspect ratio ($L/d$) and volume fraction of steel fiber ($V_f$) on fracture properties of concrete in bending were investigated by measuring the fracture energy ($G_f$) and characteristic length ($l_{ch}$). For optimization, three-level full factorial experimental design and response surface method were used. The results show that the effects of fiber volume fraction and aspect ratio on fracture energy and characteristic length are very significant. The density of coarse aggregate was 2.65 g/cm³. The amount of high range water reducing admixture varied between 0.75 % and 1.5 % by weight of cement for different concrete mixtures to maintain sufficient workability. The volume fractions of steel fibers were 0.26 %, 0.45 %, and 0.64 % and the aspect ratios of fibers ($L/d$) were 55, 65, and 80.

Calogero and et al.[63] have presented the results of experimental tests carried out on rectangular simply supported beam made of hooked steel fiber reinforced concrete with and without stirrups, subjected to two point symmetrically placed vertical loads. The ultimate values of the shear stresses recorded experimentally are compared with the corresponding values deduced by semi empirical expressions available in the literature and the correlation is satisfactory. Hooked end steel fibers were used; they were joined together by a water soluble glue to ensure good dispersion in the concrete. The fibers had the following characteristics: length $L_f$ = 30 mm; equivalent diameter $D_f$ = 0.5 mm (aspect ratio $L_f/D_f$ = 60); nominal tensile strength of 1115 MPa. Two volume percentages of fibers, $V_f$ = 1 % and 2 % with respect to the volume of concrete, were used, equivalent to 80 and 160 kg/m³ respectively. Addition of fibers reduces the workability of the fresh concrete; a super plasticizer with a dosage of 1.5 % by weight of cement was added to the mixes.

Hamad and et al.[64] has reported that FRP sheets or wraps as alternative, efficient tools (besides transverse reinforcement and steel fibers) to improve the bond strength and ductility of the mode of failure of tension lap splices anchored anchored HSC beams. What makes the study significant is that the experimental results of ten HSC beams were used to perform an analytical to propose a new FRP confinement parameter $k_{trf}$ analogous to the ACI parameter for transverse reinforcement of anchored steel bars $k_{tr}$. This parameter, however, should be validated in future research where more variables such as concrete strength, steel bar size, and specimen type and size, are investigated.

Harajli[65], has made a comparative analytical study of the average bond strength at failure of reinforcing bars embedded in unconfined normal strength concrete (NSC) and high strength concrete (HSC) is undertaken. The analysis makes use of an experimentally derived local bond stress slip model and considers the progressive bond deterioration.
along the development splice length with the increase in bar force. Results of the average bond strength or development/splice strength predicted by the analysis showed excellent agreement with experimental data for both NSC and HSC.

Lokand and Zhao,[66] has suggested the uniaxial compressive response of steel fiber reinforced concrete (SFRC) subjected to high strain rate loading is presented. Details of an experimental investigation using a 75 mm diameter split Hopkinson pressure bar (SHPB) are outlined. The investigation focuses on recorded data and results in distinguishing the strain rate that mobilizes ductility of steel fiber reinforced concrete. Per volume fraction was 0.6 %. Three 100 mm cubes and three 70 mm diameter by 140 mm long cylinders were case and tested to obtain their static strengths. The average uniaxial compressive strength of the cubes was 91 MPa.

Granju and Balouch,[67] has reported widely that in case of steel fibers reinforced concrete (SFRC), corrosion is less active as compared with steel bars. In the cracked section, the durability of the material depends on the performance of the bridging capacity of the fibers embedded in the concrete. The corrosion of the fibers not only could produce the spalling of concrete but it could also reduce the sectional area of the fibers, turning the durability of structures in danger. This study focuses on those two aspects of fiber corrosion.

Miloud,[68] has made an experimental study to examine the influences of steel fiber addition on the permeability and porosity of a concrete prepared mainly from local materials. The test results are discussed in this paper, the interpretation of the test results is reported as well as conclusions regarding the effects of steel fibers on the water and gas permeability of concrete.

Khaloo and Afshari,[69] has studied the Influence of length and volumetric percentage of steel fibers on energy absorption of concrete slabs with various concrete strengths is investigated by testing 28 small steel fiber reinforced concrete (SFRC) slabs under flexure. Variables include; fiber length, volumetric percentage of fibers and concrete strength. Test results indicate that generally longer fibers and higher fiber content provide higher energy absorption. The results are compared with a theoretical prediction based on random distribution of fibers. The volumetric percentages of steel fibers, i.e., the ratios of the volume of fibers to the volume of matrix were 0.5, 1.0 and 1.5, which correspond to 25, 50 and 75 kg of steel fibers for mix proportions used in the test.

Mohammadi and Kauushik [70], have investigated the fatigue life distribution of plain and steel fiber reinforced concrete with different fiber volume fractions and aspect rations.
for various levels of the applied fatigue stress. Fiber aspect ratios of 20 and 40, respectively, were used at each of the fiber volume fraction of 0, 1.0, 1.5 and 2.0 %. It has been observed that the probabilistic distribution of fatigue life can be approximately modeled using the two parameter Weibull distribution with statistical correlation coefficient exceeding 0.90. The shape parameter of the Weibull distribution for the fatigue life of concrete is different for different stress levels and fiber aspect ratios. The present study indicates that the probabilistic distribution on fatigue life of concrete depends on the level of applied fatigue stress, fiber volume fraction, and the aspect ratio of fibers.

Lau & Anson [71] have studied effect of high temperatures on high performance steel fiber reinforced concrete. The compressive strength, flexural strength, elastic modulus and porosity of concrete reinforced with 1 % steel fiber (SFRC) and changes of colour to the heated concrete have been investigated. The results show a loss of concrete strength with increase maximum heating temperature and with increased initial saturation percentage before firing. For maximum exposure temperatures below 400 °C High performance concretes (HPC) start to suffer a greater compressive strength loss than normal strength concrete (NSC) at maximum exposure temperatures of 600 °C.

GozdeInan & Tabak [72] have studied the effects of aspect ratio (I/d) and volume fraction (Vf) of steel fiber on the compressive strength, split tensile strength, flexural strength and ultrasonic pulse velocity of steel fiber reinforced concrete (SFRC) were investigated. For this purpose, hooked end steel fibers with three different I/d ratios of 45, 65 and 80 were used. Three different fiber volumes were added to concrete mixes at 0.5 %, 1.0 % and 1.5 % by volume of concrete. Ten different concrete mixes were prepared. After 28 days of curing, compressive, split and flexural strength as well as ultrasonic pulse velocity were determined. It was found that, inclusion of steel fibers significantly affect the split tensile and flexural strength of concrete according to I/d ration and Vf. Besides, mathematical expressions were developed to estimate the compressive, flexural and split tensile strength of SFRCs regarding I/d ratio and Vf of steel fibers.

Zerbino and et al [73] have studied the benefits produced by the use of high strength (HSC) concrete in structures include the increase in the load carrying capacity, durability and, consequently, longer service life nevertheless, concrete with higher strength exhibits more brittle behavior. This phenomenon can be compensated by the incorporation of distributed steel fiber reinforcement. This paper analyses the behavior of steel fiber reinforced high strength concrete, with emphasis on toughness parameters demined
through the ASTM C 1018 procedure. The effects of matrix strength level, fiber type and dosage have been studied. The geometry of the specimens and loading configuration have also been varied. In addition, the failure mechanism under compressive loading has been analyzed using the critical stress concept.

N. Ganesan and et al [74] have studied experiment conducted to study the effect of steel fibers 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 fibers. The water cement ratio of 0.36 by weight and a trinity 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 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 observes that SFRSCC resists the attacks within tolerable limits and the optimum dosage of fibers for better performance was found to be 0.5 percent.

Sharma and et al [75] have studied experimental investigation of steel fiber reinforced high strength concrete short columns confined by circular spirals under monotonically increasing concentric compression. The test variables included aspect ratio, volume fraction of crimped steel fibers and volumetric ratio of transverse spiral reinforcement. The effects of these variables on the uniaxial behavior of high strength concrete columns are presented and discussed. The results indicate that addition fibers to the high strength concrete mix prevented the early spalling of the cover and increase the load carrying capacity and ductility of the columns as compared to non-fiber columns.

Lakshmanan and et al [76] have studied experimental investigations conducted on SFRC beams with web reinforcement to evaluate the shear strength and development of an analytical model to predict the shear strength of the test beams. It is seen that the shear carried by concrete is far more in SFRC beams and hence sufficient anchorage for longitudinal steel has to be provided. Care should be taken while giving cutting lengths schedule to ensure necessary anchorage. A good agreement between the experimental and theoretical shear capacities of steel fiber reinforced concrete beams with a shear span to depth ration of 2.0, suggests the validity of the above mathematical modeling.

Kuder and et al [77] have studied experimental rheology of fiber reinforced cementitious materials In this study, a parallel plate rheometer is designed and built to evaluate the
flow behavior of stiff fiber reinforced systems. Initial experiments are conducted to verify that the rheometer provides reasonable results and to develop appropriate experimental procedure. The effects of water/cement ratio and sand addition on the flow behavior of cement paste systems are determined. Finally, the influence of steel fibers on the rheology of stiff fiber reinforced systems is evaluated. Steel fiber reinforced cement paste was determined. Two w/c, 0.30 and 0.35, with three fiber volume contents, 1 %, 2 % and 4 %, were studied. For both w/cm the yield stress decreases until a critical volume fraction is reached, and then increases. The viscosities appear to decrease until reaching a critical point, however, the decrease for the stiffer matrix, with w/c=0.30, is much greater. At fiber dosage of 4 % the yield stress and viscosity are similar for both w/c.

Fatih Altun and et al [78] have studied the effects of steel fiber addition on mechanical properties of concrete and RC Beams. In this research study, the effect of SFs on cracks in RC beams was investigated, and it was conclude that a SF dosage of 30-40 kg/m3 was appropriate to have an appreciable improvement on cracks, studied the contribution of SFs of RC beams and determined that a SF dosage of 1-2 % by absolute volume was ideal from that aspect. The optimum SF dosage for SFARC beams should be within the range of 1-25 % by absolute volume. A SF dosage smaller than 1 % becomes ineffective and dosages beyond 2.5 % become also ineffective mainly due to the physical difficulties in providing a homogeneous distribution of the fibers within the concrete causing an appreciable deep in the compressive strength as compare to the plan concrete of the same class.

Sivakumar and et al [79] have studied the investigation carried out on high strength concrete reinforced with hybrid fibers (combination of hooked steel and a non-met allic fiber) up to a volume fraction of 0.5 %. The mechanical properties, namely, compressive strength, split tensile strength, flexural strength and flexural toughness were studied for concrete prepared using different by bird fiber combinations steel polypropylene, steel polyester and steel glass. The flexural properties were studied using four point bending tests on beam specie specimens Japanese Concrete Institute (JCI) recommendations. Fiber addition was seen to enhance the pre-peak as well as post peak region of the load deflection curve, causing an increase in flexural strength and toughness, respectively. Addition of steel fibers generally contributed towards the energy absorbing mechanism (bridging action) whereas, the non-met allic fibers resulted in delaying the formation of micro cracks. Compared to other hybrid fiber reinforced concretes, the flexural toughness of steel polypropylene hybrid fiber concretes was comparable to steel fiber concrete.
Increased fiber availability in the hybrid fiber systems (due to the lower densities of nonmetallic fibers), in addition to the ability of non-metallic fibers to bridge smaller micro cracks, are suggested as the reasons for the enhancement in mechanical properties. Job Thomus and et al [80] have studied the assessment of fibers on mechanical properties of concrete. Models derived based on the regression analysis of 60 test data for various mechanical properties of steel fiber reinforced concrete have been presented. The various strength properties studied are cube and cylinder compressive strength, split tensile strength, modulus of rupture and post cracking performance, modulus of elasticity, Poisson’s ratio, and strain corresponding to peak compressive stress. The variables considered are grade of concrete, namely, normal strength (35 MPa), moderately high strength (65 MPa), and high strength concrete (85 MPa) and the volume fraction of the fiber (Vf=0.0, 1.0, and 1.5 %)

Baruah and et al [81] have studied comparative study to determine the compressive strength, modulus of rupture, split tensile and strength of concrete made using fibers of five different origins. The fibers used were steel fiber of two different sizes, polyester fiber, E-glass fibers and two naturally occurring fibers (white jute and coconut coir). Ordinary concrete M20 was designed using Portland cement and locally available fine and coarse aggregate. Fibers of various types were used in volume fractions ranging from 0.5 % to 2.0 %. From load deflection curve obtained in flexural test, toughness indices were calculated. The improvement in mechanical properties in steel fiber reinforced concrete is found to be the best followed by concrete containing polyester, glass, coir and jute fibers.

Premalatha and et al [82] have studied influence of steel fibers on these strength properties of high strength concrete has been investigated. No significant increase in compressive strength was observed due to the addition of steel fiber content of 1.5 % by volume of concrete. However, it resulted in increase of splitting tensile strength and modulus of rupture by 62 % and 80 %, respectively.

Swamy and et al [83] have studied sustainable concrete for the 21st century concept of strength through durability. The current emphasis on high strength and very high strength, and the design philosophy of durability through strength for concrete materials and concrete structures is fandom fundamentally. It is this is leading concept and vision that is primarily responsible for the lack of durable performance of concrete in real life environments. If concrete is to be an eco-friendly, and sustainable driving force and construction material for social change, the need is to produce durable concrete with
strengths of 30 to 60 to 80 MPa rather than very high strength concrete without an assured durable performance.

Francesco Bennardino and et al [84] have studied the results of tests in compression of steel fiber reinforced concrete carried out according to standard procedure, and a critical evaluation of the models proposed to define the stress strain behavior in cp, impression. The tests reported were carried out on cylindrical specimens of plain and steel fiber reinforced concrete with fiber volume of 1, 1.6 and 3%. To evaluate the reliability of the models available in literature, a critical comparative study was carried out between the experimental data and the various proposed theoretical stress strains relationships.

Giuseppe Campione and et al [85] have studied the simplified flexural response of steel fiber reinforced concrete beams. An analytical model was proposed that is able to determine the flexural response of supported beams under four point bending tests. Cases of normal strength reinforced concrete beams with longitudinal bars in the presence of reinforcing hooked steel fibers and transverse stirrups are considered. A simplified analytical model is presented that is able to calculate the load deflection curves and the maximum and ultimate deflections occurring in the case of shear or flexure failures.

Mansur and et al [86] have studied the shear transfer behavior of reinforced concrete across a crack is investigated both analytically and experimentally by conducting tests on 19 pre-cracked push off specimens. The major parameters considered are the compressive strength of concrete and reinforcement parameter through the shear plane. Test results indicate that the behavior of a crack during shear transfer is characterized by four significant events. A large pool of test data on reinforced concrete has been collated from the available literature. These, together with the test data generated in this study, have been analyzed and modeled embracing concrete strength up to about 110 MPa for predicting the ultimate shear transfer strength across a crack. A comparison of theoretical prediction with available test results shows good agreement.

Beatrice and et al [87] have studied the fracture behavior of steel fiber reinforced concrete (SFRC) slabs on grade for industrial pavements is presented. Finite element analyses have been carried out by using a commercial finite element code where user subroutines based on nonlinear fracture mechanics have been implemented to describe the progressive cracking behavior of SFRC. A real pavement with contraction or construction joints has been numerically simulated to investigate the stress and the strain fields for the most significant positions of point loads.
Cengiz Duran Atis and et al [88] have studied the influence of using fly ash, polypropylene fiber, and steel fiber in concrete on abrasion resistance is presented. Seven concrete minutes containing 0, 10, 15, 25, 30 and 45 % fly ash as cement replacement in mass basis were and 0.2 % polypropylene fiber in volume basis were prepared. Another, seven fiber reinforced Portland cement concrete mixtures containing 0, 25, 0.5, 1 and 1.5 % steel fiber and 0.05, 0.1, and 0.2 % polypropylene fiber in volume basis were prepared. These seven fibers reinforced Portland cement concrete mixtures were modified by replacing 15 and 30 % fly ash with cement in mass basis, consequently, 14 fiber reinforced fly ash concrete mixture were prepared. Water binder ratio was kept constraint at 0.3-.35 for all concrete mixtures. The comparison between the relation of abrasion to compressive strength and abrasion to flexural tensile strength, made in terms of R2 of the linear regression on log scale, showed that a stronger relation existed between abrasion and flexural tensile strength than between abrasion and compressive strength of the concrete containing either fly ash or fibers or both.
<table>
<thead>
<tr>
<th>fibers used</th>
<th>content</th>
</tr>
</thead>
<tbody>
<tr>
<td>G. Batson</td>
<td>2 to 2.98 %</td>
</tr>
<tr>
<td>Charles H. Henager</td>
<td>1%</td>
</tr>
<tr>
<td>Colin D.</td>
<td>1%</td>
</tr>
<tr>
<td>Marks E Pattern</td>
<td>1.8%</td>
</tr>
<tr>
<td>R. Sri Ravinrarajah</td>
<td>0.25, 0.50, and 0.75%</td>
</tr>
<tr>
<td>F.S. Rastogy</td>
<td>0, 1 and 3%</td>
</tr>
<tr>
<td>A E Naamam</td>
<td>1.2 and 3%</td>
</tr>
<tr>
<td>J.A. Puurkiss</td>
<td>1.5% (crimped)</td>
</tr>
<tr>
<td>Leanard</td>
<td>1.5%</td>
</tr>
<tr>
<td>Colin</td>
<td>0.5 to 1.5%</td>
</tr>
<tr>
<td>Niema</td>
<td>0.4 to 1 %</td>
</tr>
<tr>
<td>Sameer E zeldin</td>
<td>0 to 1.5%</td>
</tr>
<tr>
<td>Samir A. Ashour</td>
<td>1.5%</td>
</tr>
<tr>
<td>S Undess L Chen</td>
<td>0.0, 0.5, 0.75, 1.0 and 1.5%</td>
</tr>
<tr>
<td>K. H. Tan</td>
<td>1%</td>
</tr>
<tr>
<td>A. E. Naaman</td>
<td>2%</td>
</tr>
<tr>
<td>Jenn-chnan chem.</td>
<td>0 to 2%</td>
</tr>
<tr>
<td>Ginseppe campime</td>
<td>1.5, 2 and 3%</td>
</tr>
<tr>
<td>Mariade curdes</td>
<td>0.8% by volume</td>
</tr>
<tr>
<td>M. M. Khomyansky</td>
<td>0 to 1.5%</td>
</tr>
<tr>
<td>M. Harajli and K Karam</td>
<td>1 &amp; 2% respectively</td>
</tr>
<tr>
<td>Singh and Kanshik</td>
<td>1.5%</td>
</tr>
<tr>
<td>Balagum and H Najm</td>
<td>0 to 3.75%</td>
</tr>
<tr>
<td>Poori and etal</td>
<td>0.5 to 1 %</td>
</tr>
<tr>
<td>Padmarajaiah &amp; Ramaswamy</td>
<td>0 to 1.5 %</td>
</tr>
<tr>
<td>Bayramov and atal</td>
<td>0.26%, 0.45% and 0.64%</td>
</tr>
<tr>
<td>Calogero and etal</td>
<td>1% and 2%</td>
</tr>
<tr>
<td>Lokand and Zhao</td>
<td>0.6%</td>
</tr>
<tr>
<td>Khaloo and Afshori</td>
<td>0.5, 1.0 and 1.5%</td>
</tr>
<tr>
<td>Yaghoub Mohmmadi</td>
<td>0.1, 1.5 and 2%</td>
</tr>
<tr>
<td>A. Lan and M. Anson</td>
<td>1%</td>
</tr>
<tr>
<td>Gozdelnan and Volkan Tabak</td>
<td>0.5, 1 and 1.5%</td>
</tr>
<tr>
<td>N. Ganesan and etal</td>
<td>0, 0.25, 0.5 and 0.75%</td>
</tr>
</tbody>
</table>
Katherine G. Kuder 1, 2 and 4%
Fatih Atlum 1-2%
A. Sivakumar upto 0.5%
Job Thomns and etal 0.1 and 1.5%
P.Baruali and atal 0.5 to 2%
J Premalatha 1.5%
Francesco Bemcardino 1, 1.6 and 3%
Cengiz Duran Atis 1 and 1.5 % steel fiber