

# [Steel fiber reinforced mechanisms](https://assignbuster.com/steel-fiber-reinforced-mechanisms/)

Compared to other building materials such as metals and polymers, concrete is significantly more brittle and exhibits a poor tensile strength. Based on fracture toughness values, steel is at least 100 times more resistant to crack growth than concrete. Concrete in service thus cracks easily, and this cracking creates easy access routes for deleterious agents resulting in early saturation, freeze-thaw damage, scaling, disconsolation and steel corrosion.

The concerns with the inferior fracture toughness of concrete are alleviated to a large extent by reinforcing it with fibers of arioso materials. The resulting material with a random distribution of short, discontinuous fibers is termed fiber reinforced concrete (FRR) and is slowly becoming a well accepted mainstream construction material. Significant progress has been made in the last thirty years towards understanding the short and long-term performances of fiber reinforced conscientious materials, and this has resulted in a number of novel and innovative applications.

There are currently 200, 000 metric tons of fibers used for concrete reinforcement. Steel fiber remains the most used fiber of al (50% of total tonnage used) followed by polypropylene (20%), glass (5%) and other fibers (25%). : Reinforcement Mechanisms: Concrete carries flaws and micro-cracks both in the material and at the interfaces even before an external load is applied. These defects and micro-cracks emanate from excess water, bleeding, plastic settlement, thermal and shrinkage strains and stress concentrations imposed by external restraints.

Under an applied load, distributed micro-cracks propagate coalesce and align themselves to produce macro- racks. When loads are further increased, conditions of critical crack growth are attained at the tips of the macro-cracks and unstable and catastrophic failure is precipitated. The micro and macro-fracturing processes described above, can be favorably modified by adding short, randomly distributed fibers of various suitable materials. Fibers not only suppress the formation of cracks, but also abate their propagation and growth.

Soon after placement, evaporation of the mix water and the toughness process of concrete hydration create shrinkage strains in concrete. If strained, this contraction can cause stresses far in excess of those needed to cause cracking. In spite of every effort, plastic shrinkage cracking remains a serious concern, particularly in large surface area placements like slabs on grade, thin surface repairs, patching and shoetree linings. With large surface areas, fibers engage water in the mix and reduce bleeding and segregation.

The result is that there is less water available for evaporation and less overall free shrinkage. When combined with post-crack bridging capability of fibers, fibers reduce crack widths and racks areas when concrete is retrained. In the hardened state, when fibers are properly bonded, they interact with the matrix at the level of micro-cracks and effectively bridge these cracks thereby providing stress transfer media that delays their coalescence and unstable growth. F the fiber volume fraction is sufficiently high, this may result in an increase in the tensile strength of the matrix. Once the tensile capacity of the composite is reached, and coalescence and conversion of micro-cracks to macro-cracks has occurred, fibers, depending on their length and bonding heartsickness continue to restrain crack opening and crack growth by effectively bridging across macro-cracks. This post-peak macro-crack bridging is the primary reinforcement mechanism in the majority of commercial fiber reinforced concrete composites. Fiber-reinforced conscientious composites can be classified into two broad categories: normal performance (or conventional) fiber-reinforced conscientious composites and high-performance fiber-reinforced conscientious composites. In FRI.. With low to medium volume fraction of fibers, fibers do not enhance the tensile/flexural strength of the composite and benefits of fiber enforcement are limited to energy absorption or toughness enhancement in the post-cracking regime only.

For high performance fiber reinforced composites, on the other hand, with a high fiber dosage, benefits of fiber reinforcement are noted in an increased tensile strength, strain-hardening response before localization and enhanced toughness beyond crack localization. Fiber-Matrix Bond: As in any fiber reinforced composite, fiber-matrix bond in FRR is of critical importance. However, unlike fiber reinforced polymers (Fri..) used in aerospace and automobile industries where fibers are employed to enhance strength and elastic dulls, in FRI.. Toughness or energy absorption capability is of primary interest.

Therefore, inelastic bond failure mechanisms such as interracial crack growth, crack tortuously and fiber slip are of greater relevance. Fiber pull-out tests are often performed to assess fiber efficiency in FRR and in such tests fiber bond and slip are monitored simultaneously. For a fiber embedded in a conscientious matrix and subjected to a pull-out load, shear-lag will occur and interracial defending will commence at the point of fiber entry which will slowly propagate towards the free end of the fiber.

Thus, some energy absorption will occur at the fiber-matrix interface while the bond is being embroiled and the fiber prepares to slip. Early in the development of fiber reinforced concrete it became apparent that for large, macro- fibers with small surface areas, a straight fiber will pull-out at low values of interracial stress and will generate stress in fiber far below its tensile strength. Most commercial macro-fibers of steel and other materials (polypropylene, for example) are now deformed to enhance their bond with the surrounding matrix. However, even here there is a limit.

If deformed excessively, fibers may develop stresses that exceed their strength and fracture in the process. The energy absorption in such cases is limited, and although some fiber slippage may precede fracture, poor toughening ensues. For maximized fiber efficiency, a pull-out mode of fiber failure where pull-out occurs at a fiber stress close to its tensile strength is preferred. It is important to mention that fiber failure mode is highly dependent on the angle at which fiber is inclined with respect to the direction of the pull-out force. Steel Fiber Reinforced Concrete (SAFER)

Concrete is the most widely used structural material in the world with an annual production of over seven billion tons. For a variety of reasons, much of this concrete is cracked. The reason for concrete to suffer cracking may be attributed to structural, environmental or economic factors, but most of the cracks are formed due to the inherent weakness of the material to resist tensile forces. Again, concrete shrinks and will again crack, when it is restrained. It is now well established that steel fiber reinforcement offers a solution to the problem of cracking by making concrete tougher and more ductile.

It has also been proved by extensive research and field trials carried out over the past three decades, that addition of steel fibers to conventional plain or reinforced and overstressed concrete members at the time of mixing/production imparts improvements to several properties of concrete, particularly those related to strength, performance and durability. The weak matrix in concrete, when reinforced with steel fibers, uniformly distributed across its entire mass, gets strengthened enormously, thereby rendering the matrix to behave as a composite material with properties significantly different from invitational concrete.

The randomly-oriented steel fibers assist in controlling the propagation of micro-cracks present in the matrix, first by improving the overall cracking resistance of matrix itself, and later by bridging across even smaller cracks formed after the application of load on the member, thereby preventing their widening into major cracks . Failure mechanism and the effect of fibers: The idea that concrete can be strengthened by fiber inclusion was first put forward by Porter in 1910, but little progress was made in its development till 1963, when

Armorial and Baton carried out extensive laboratory investigations and published their classical paper on the subject. Since then, there has been a great wave of interest in and applications of SAFER in many parts of the world. While steel fibers improve the compressive strength of concrete only marginally by about 10 to 30%, significant improvement is achieved in several other properties of concrete. Different types of steel fibers In general, SAFER is very ductile and particularly well suited for structures which are required to exhibit: Resistance to impact, blast and shock loads and high fatigue

Shrinkage control of concrete (figuration) Very high flexural, shear and tensile strength Resistance to splitting/spilling, erosion and abrasion High thermal/ temperature resistance Resistance to seismic hazards. The degree of improvement gained in any specific property exhibited by SAFER is dependent on a number of factors that include Concrete mix and its Steel fiber content Fiber shape, its aspect ratio. The efficiency of steel fibers as concrete macro-reinforcement is in proportion to increasing fiber content, fiber strength, aspect ratio and bonding efficiency of the fibers in the concrete matrix.

The efficiency is further improved by deforming the fibers and by resorting to advanced production techniques. Any improvement in the mechanical bond ensures that the failure of a SAFER specimen is due mainly to fibers reaching their ultimate strength, and not due to their pull-out. Workability We know that it is usually wrong to add water to concrete for workability. The main problem with workability of steel fiber reinforced concrete is in getting proper distribution of the fibers so that they don't ball up. Ђ This difficulty is usually overcome by slow, continuous and uniform feeding of the fibers into the wet or dry mix by meaner of vibratory feeders. Sometimes the fibers are passed through screens as they are introduced. Proper feeding can virtually eliminate the problem of balling. On the other hand, addition of water to improve workability can reduce the flexural strength significantly, a critical matter when one considers that one of the main reasons for using steel fibers is to improve the flexural strength. Ђ In such cases use of suitable admixture probably would improve the workability to certain extent ND may not to the extent that you require. Applications of SAFER The applications of SAFER depend on the ingenuity of the designer and builder in taking advantage of its much enhanced and superior static and dynamic tensile strength, ductility, energy absorbing characteristics, abrasion resistance and fatigue strength. Growing experience and confidence by engineers, designers and contractors has led to many new areas of use particularly in precept, cast in-situ, and shoetree applications.

Traditional application where SAFER was initially used as pavements, has now gained wide acceptance in the construction of a number of airport runways, heavy-duty and container yard floors in several parts of the world due to savings in cost and superior performance during service. The advantages of SAFER have now been recognized and utilized in precept application where designers are looking for thinner sections and more complex shapes.

Applications include building panels, sea-defense walls and blocks, piles, blast-resistant storage cabins, coffins, pipes, highway Krebs, prefabricated storage tanks, composite panels and ducts. Precept fiber reinforced concrete manhole covers and frames are being widely used in India, Europe and USA. Cast in-situ application includes bank vaults, bridges, nosing Joints and water slides. " Sprayed-in" ground swimming pools is a new and growing area of shoetree application in Australia.

SAFER has become a standard building material in Scandinavia. Applications of SAFER to bio-logical shielding in atomic reactors and also to waterfront marine structures which have to resist deterioration at the air-water interface and impact loadings have also been successfully made. The latter category includes Jetty armor, floating pontoons, and caissons. Easiness with which fiber concrete can be McCollum document curves sakes it attractive for ship hull construction either alone or in conjunction with fermented.

SAFER shoetree has recently been used for sealing the recesses at the anchorages of post stressing cables in oil platform concrete structures. Recent developments in fiber types and their geometry and also in concrete technology and equipment for mixing, placing and compaction of SAFER and mechanized methods for stretching have placed Scandinavian and German consultants and contractors in a front position in fiber stretching operations world wide.

Laboratory investigations have indicated that steel fibers can be used in lieu of stirrups in ARC frames, beams, and flat slabs and also as supplementary shear reinforcement in precept, thin-webbed beams. Steel fiber reinforcement can also be added to critical end zones of precept overstressed concrete beams and columns and in cast-in-place concrete to eliminate much of the secondary reinforcement.

SAFER may also be an improved meaner of providing ductility to blast-resistant and seismic-resistant structures especially at their Joints, owing to the ability of the fibers to resist deformation and undergo large tuitions by permitting the development of plastic hinges under over-load conditions. General Applications and Advantages steel fiber concrete Steel Fiber Reinforced Concrete or Shoetree (SAFER/SF) have been used in various applications throughout the world. In India their use is picking up slowly.

The principal advantages of SAFER versus plain or mesh/bar reinforced concretes are: Cost savings of 10% - 30% over conventional concrete flooring systems. Reinforcement throughout the section in all directions versus one plane of reinforcement (sometimes in the sub-grade) in only two directions. Ђ Increased ultimate flexural strength of the concrete composite and thus thinner sections. Increased flexural fatigue endurance and again thinner slabs. Increased flexural toughness, or the ability to absorb energy. Ђ Increased impact resistance and thus reduced chipping and Joint spilling. Increased shear strength and thus the ability to transfer loads across Joints in thin sections. Increased tensile strength and tensile strain capacity thus allowing increased contraction/construction Joint spacing The six major areas in which Steel Fibers can be used to achieve hi-strength, durable ND economical concrete are: a) Overlays Roads, Airfields, Runways, Container, Movement and Storage Yards, Industrial Floors and Bridges.

Advantages of using SAFER Fatigue and impact resistance increased Wear and tear resistance increased Joint spacing increased Thinner pavements possible due to higher flexural strength of SAFER Long service life with little or no maintenance b) Pre-cast Concrete Products Manhole covers and Frames, Pipes, Break-Water Units, Building Floor and Walling Components, Acoustic Barriers, Krebs, Impact Barriers, Blast Resistant Panels, Vaults, Coffins etc. Advantages of using SAFER: ЂThinner sections possible with SAFER reducing handling and transportation costs. Ђ Reduced consumption and savings in cost of materials makes pre-cast products competitive in price with cast iron or reinforced concrete products. Products possess increased ductility and resistance to chipping and cracking. SAFER products suffer less damage and loss during handling and erection Overall improvement in all structural properties Many different sizes and shapes of pre-cast units possible with SAFER. C) Hydraulic and Marine Structures Dams, Spillways, Aprons, Boats and Barges, Sea Protection Works.

Advantages of using SAFER: Outperforms conventional materials by exhibiting superior resistance to cavitations and impact damage due to wave action, hydraulic heads and swirling water currents. Ideally suitable for repair of hydraulic and marine structures d) Defense and Military Structures Aircrafts Hangers, Missile and Weaponry Storage Structures, Blast Resistant Structure, Ammunition Production and Storage Depots.