FIBER REINFORCED AND STEEL REINFORCED CONCRETE

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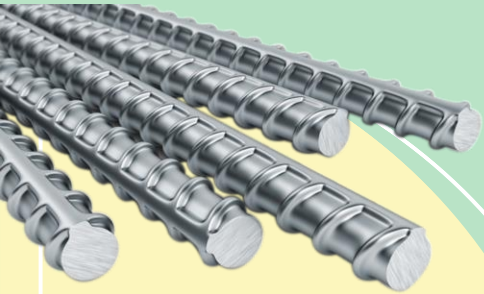


01

FIBER REINFORCED CONCRETE

- The main difference b/w conventional reinforcement and fiber reinforcement –

1. Fiber reinforcement is not a replacement for the conventional reinforcement we use.

2. Concrete & steel reinforcement act separately. Steel reinforcement is a part of a section that enhances the properties of that particular section.

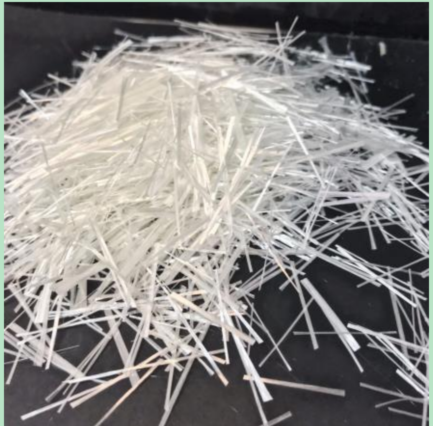
3. But the Fiber reinforcement of concrete enhances the properties of the concrete matrix itself.

FRC (Fiber Reinforced Concrete) – Composite material consisting of fibrous material which increases its structural integrity.

Consists of short, discrete, and randomly distributed fibers within the concrete matrix.

Fibers used can be of various types depending upon the requirements.

Some of the most commonly used fibers are –
glass fibers
steel fibers
polypropylene fibers, etc.



STEEL FIBERS-

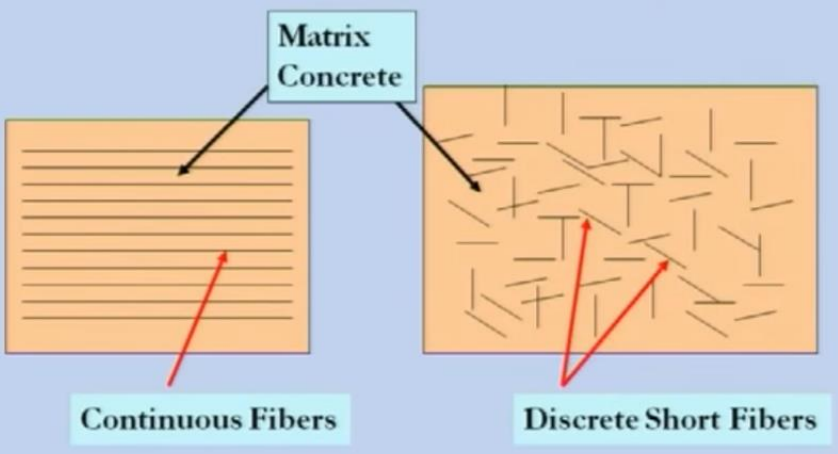
- Steel fibers are most commonly used and considered for structural use.
- Steel fibers create a network throughout the entire concrete structure.
- Fiber Length – 1.5 x maximum size of aggregates
- Can be around 30 mm or 60 mm for slabs.

  - 20 mm < l < 60 mm
  - 0.3 mm < d < 0.9 mm
  - 30 mm < Aspect Ratio < 100 mm

- Fiber content ranges between 0.5% and 2.0% by volume.
  (40 to 60 kg/m^3 by weight)
- Dimensions – 0.5 x 0.5 x 25 – 60 mm

- SFRC matrix –

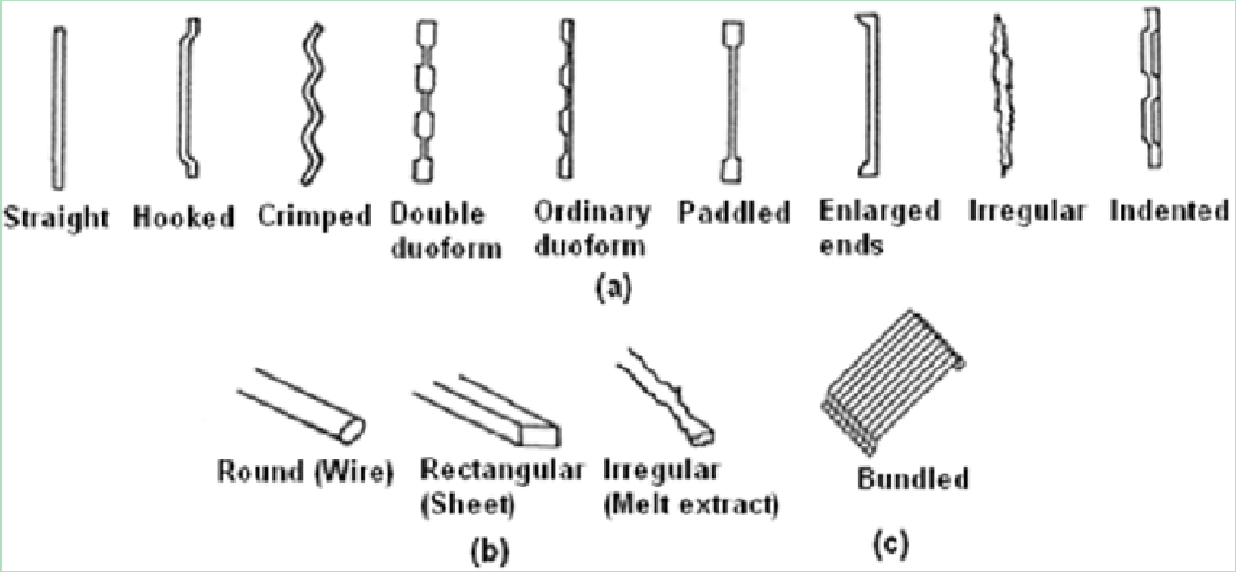
  - direction of fibers $\propto$ property of concrete in that direction
  - continuous and discrete short fibers.



- Properties of FRC depend upon –

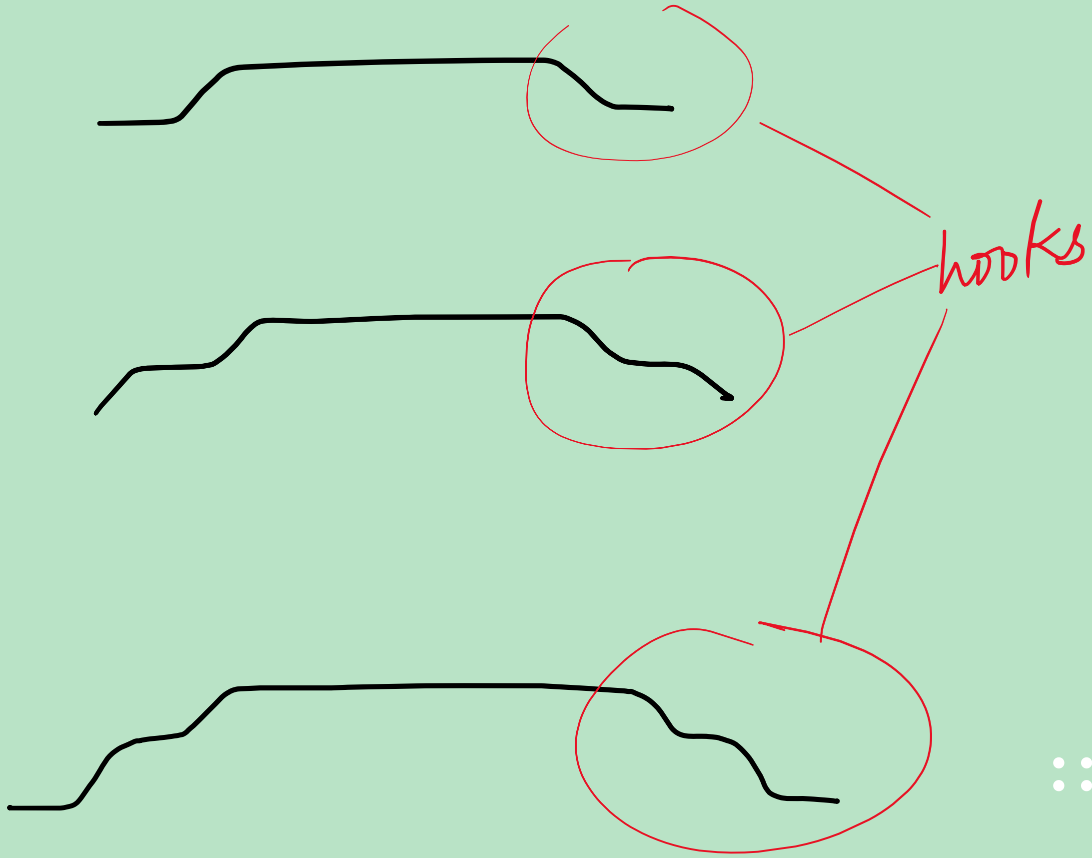
  1. Concrete
  2. Fibers

Various types of steel fibers –

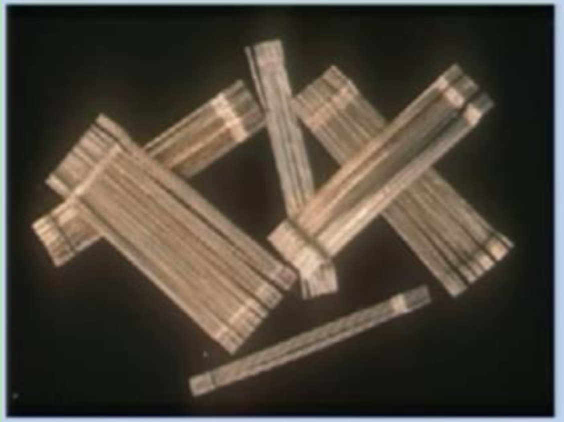


(a) steel fiber shapes, (b) steel fiber cross-sections and (c) fiber glued together into a bundle

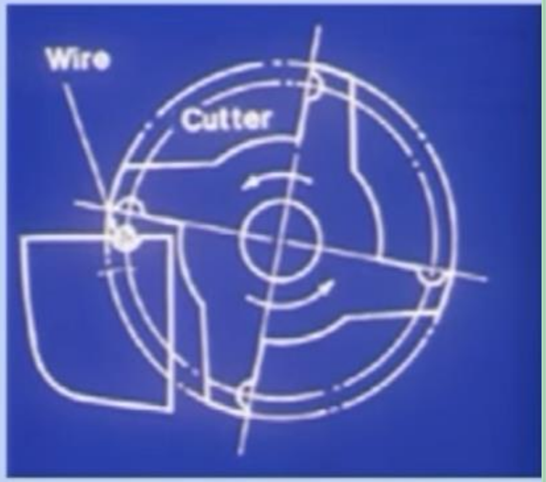
- <u>Different types of hooks –</u>

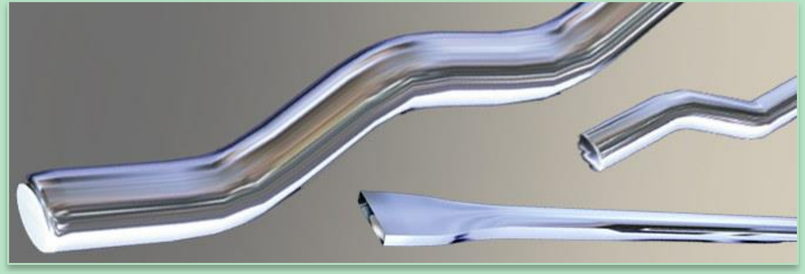


Cut-wire fiber

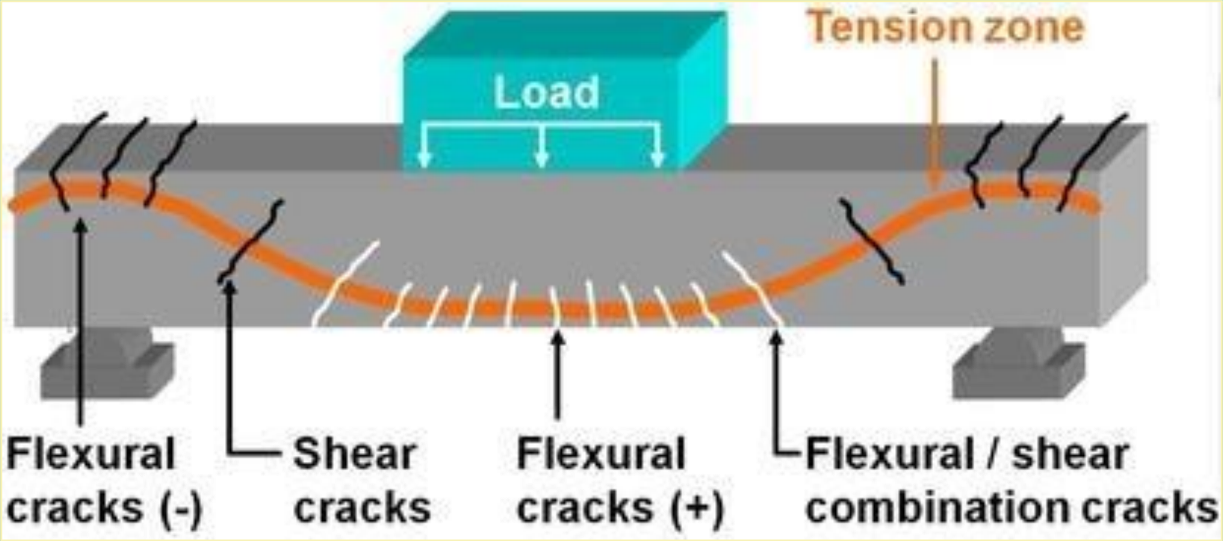


Some has indentations on the surface.





- <u>Failure in concrete –</u>

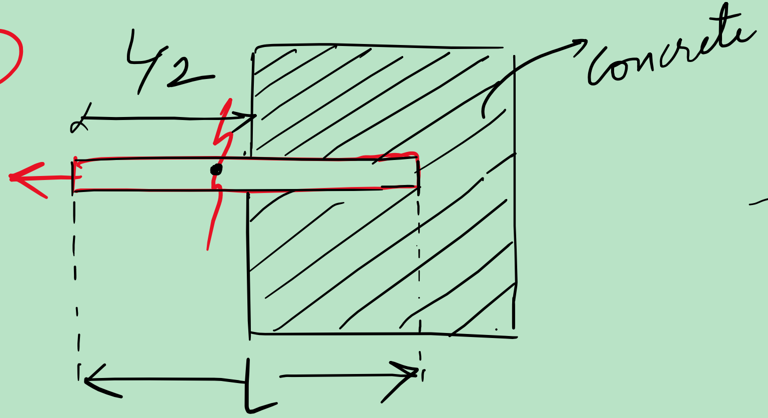


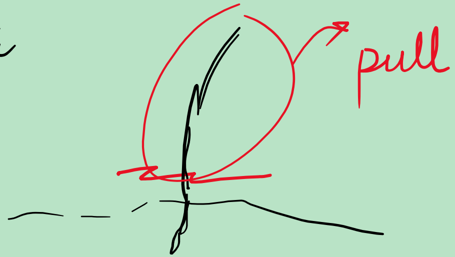
The fibers bridge the cracks and prevent them from propagating further.

- <u>Failure of fibers –</u>

1. Fiber in tension
2. Interface in bond
3. Concrete!

1





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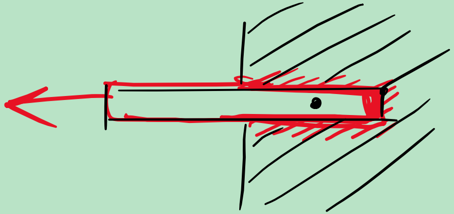

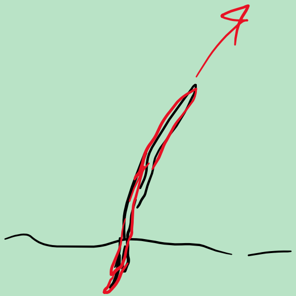

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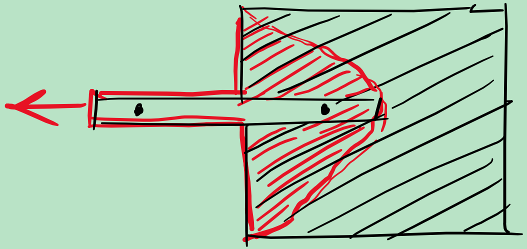
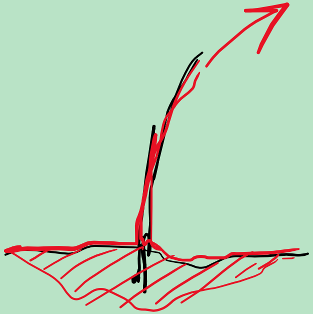
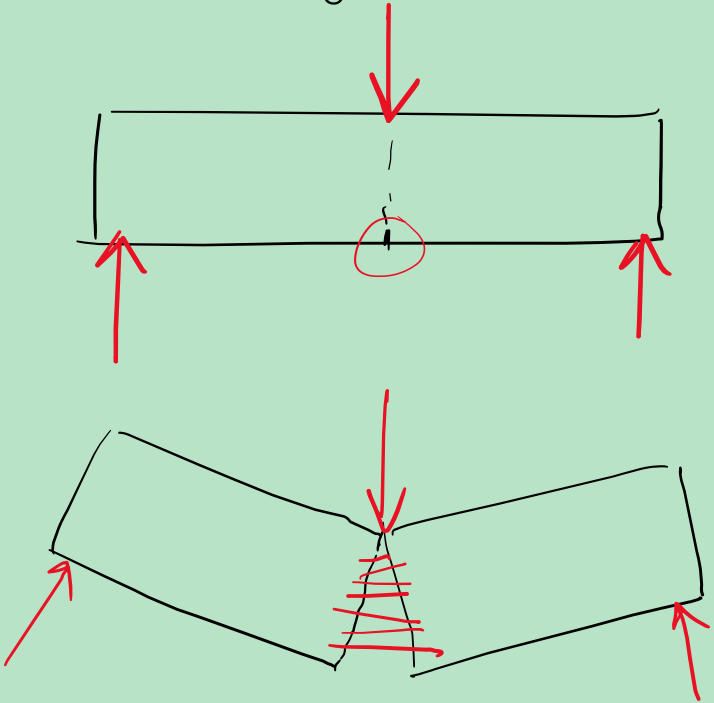


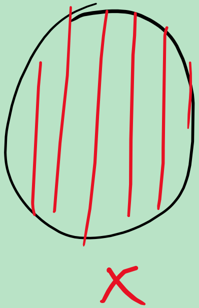


About cracks in FRC –

- Cracks are formed due to the internal stresses within the concrete matrix which results in volumetric changes.
- Mainly prevent the propagation of cracks OR prevent micro-cracks from widening.



- To hold the concrete together they must be dispersed in the right direction.
- Too short fibers may not be helpful at all.



Vf = Volume of fibers used

- Unlike plain concrete, SFRC has residual strength which can be put to use (even after cracking).

- Cracks will occur, but the failure won't result in complete collapse. SFRC can sustain a large degree of deformation of cracks at the bottom.

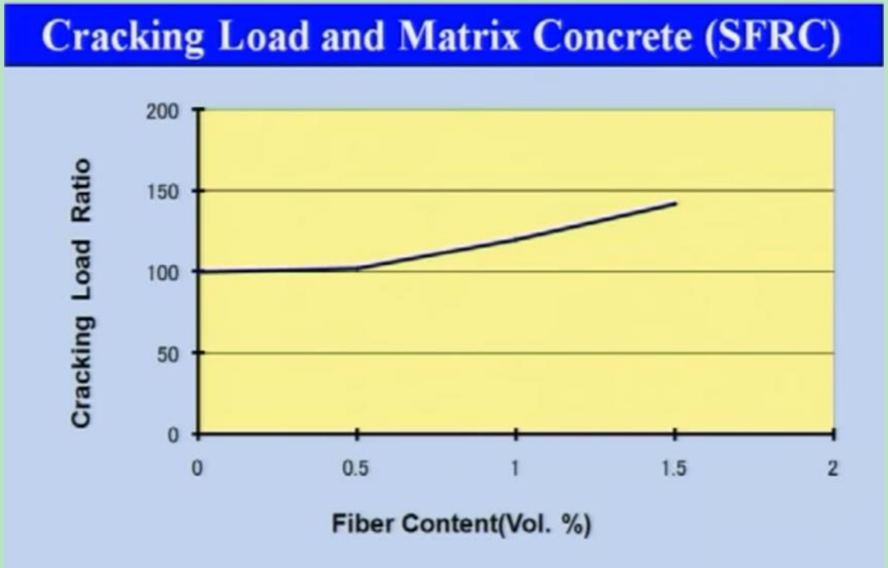
<u>Note</u> – Fibers come into play when the concrete matrix has cracked.

Cracking Load

- Cracking Load Ratio – load at which cracking will take place.

- Content of fibers $\propto$

Cracking Load Ratio
Ductility
Flexural strength
Bond strength
Toughness
Shear strength
Toughness
(energy absorption)

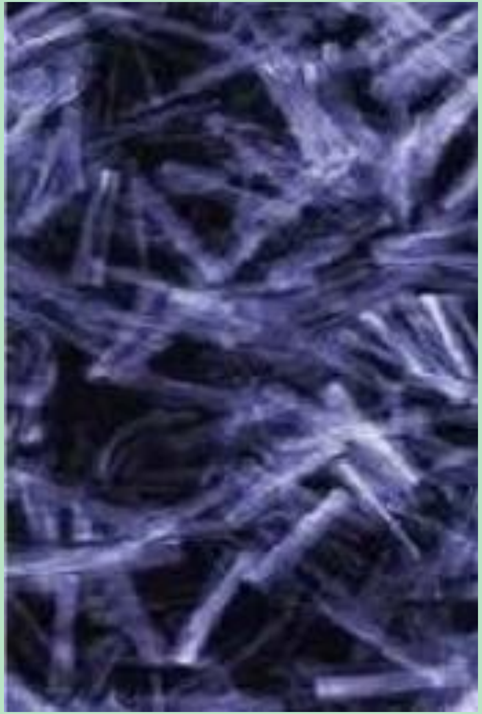


Note – Fibers come into play when the concrete matrix has cracked.

- The addition of Glass Fibers of about 10% by volume increased the tensile strength by roughly two times, and the impact resistance by about 10 times.

- The cyclic loading tests conducted on GFRC showed fatigue resistance roughly comparable with that of steel fiber reinforced concrete (SFRC).

- Uses of glass fibers in concrete are very limited because they suffer severe damage and loss of strength due to abrasion and impact forces generated during the movement of aggregates in the mixer.



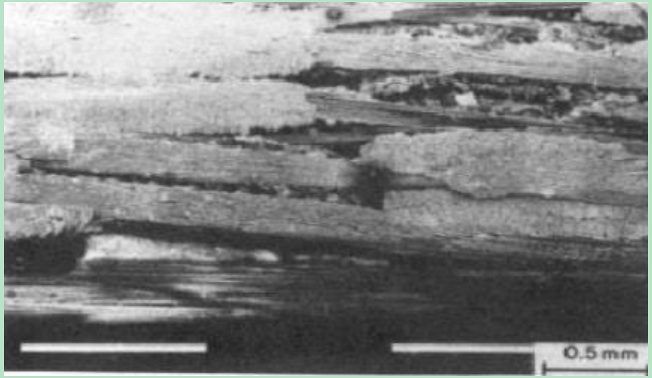
- Polypropylene is one of the cheapest & abundantly available polymers.

- Polypropylene fibers are resistant to most chemicals & don’t deteriorate first under an aggressive chemical attack.

- Its melting point is high (about 165 degrees centigrade). So that a working temp. As (100 degrees centigrade) may be sustained for short periods without detriment to fiber properties.

- Polypropylene fibers being hydrophobic can be easily mixed as they do not need lengthy contact during mixing. Polypropylene fibers are used in volume fractions between 0.5 to 15.

- <u>Carbon fibers</u> come under a very high modulus of elasticity and flexural strength.
- These are expansive.
- Their strength & stiffness characteristics have been found to be superior even to those of steel.
- They are more vulnerable to damage than even glass fiber, and hence are generally treated with resigning coating.



Advantages of using FRC –

1. Reduces drying shrinkage cracking and plastic shrinkage cracking.

2. Reduces air voids + water voids

3. Increases durability substantially.

4. Increases the energy absorption i.e. the toughness of the composite material.

5. Increase flexural and shear strength.

6. High crack arresting capability reduces crack width, and crack elongation and improves fatigue strength.

7. Post-cracking ability (ability of reinforcement and the matrix to continue to resist the deformation even after cracking).

Note – As SFRC is a composite, the reinforced fibers, and the concrete matrix, both should have similar behavior under thermal stresses. This way there would be fewer differential deformations.

Uses of SFRC –

1. On-ground floors
2. Pavements
3. Bridge decks
4. Foundations
5. Tunnel linings
6. Industrial floor slabs

- Should be a thoroughly homogenous uniform mix.
- Energy requirement is 2-4 times more than the normal concrete requirement.
  - use forced action batch mixer
  - determine the time of mixing experimentally
- For uniform dispersion -> use dispensers

OR

bundled with water-soluble adhesive & mixed

- When fibers are added in an agitating truck, concrete should be mixed at high speed for for about 30-40 revolutions.
- Ensure that the fibers do not form balls.
- Long fibers have more tendency to wrap around and form balls/lumps.

- Pumping load for SFRC is greater than for plain concrete, so the piping layout should be done appropriately. We have to consider –

  - material
  - thickness
  - diameter

- Glass fiber must not get damaged during the
  mixing of concrete.

IN CONCLUSION –

More the fiber content, the more is the need of water to increase the workability.

Fiber content $\propto$ Water demand

For an increase in 1% fiber content, the water requirement rises to 20 kg/m^3.

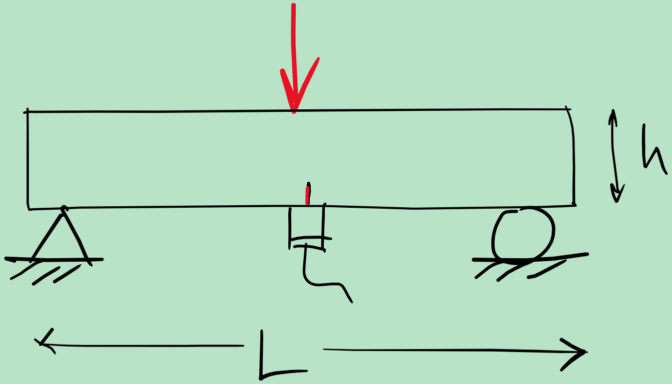
This may cause bleeding or segregation

So to minimize the water content which is our main goal, we use HRWR, Water reducing mixture so that we don’t compromise the workability.

The glass will react with alkali in the concrete, so we better use alkali-resistant glass which can be very expensive.

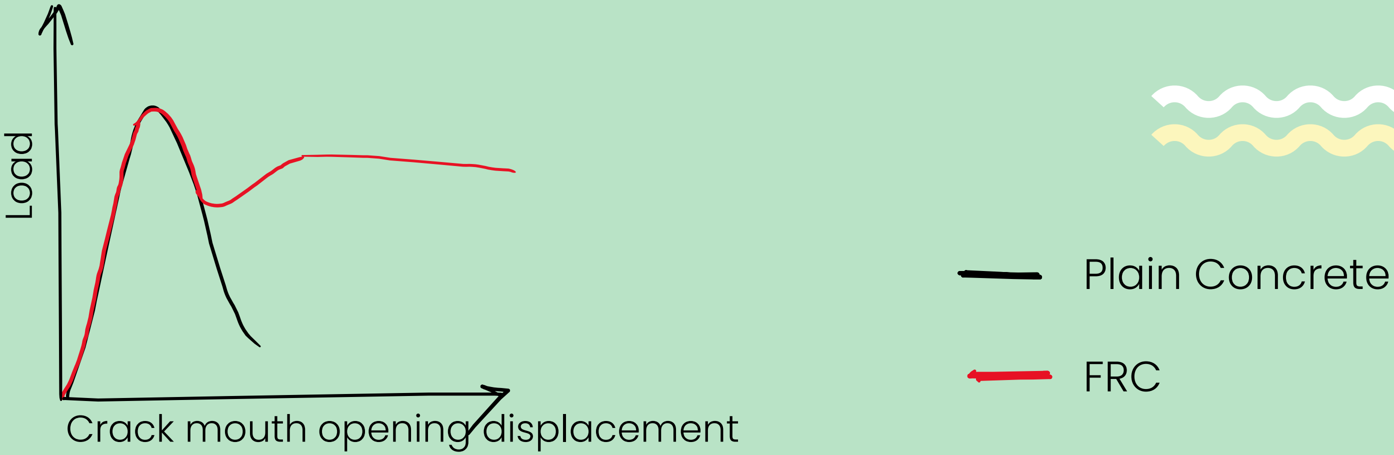
• Flexural Test –

We perform the flexural test to get post-peak behavior, using a clip gauge to monitor the cracking.



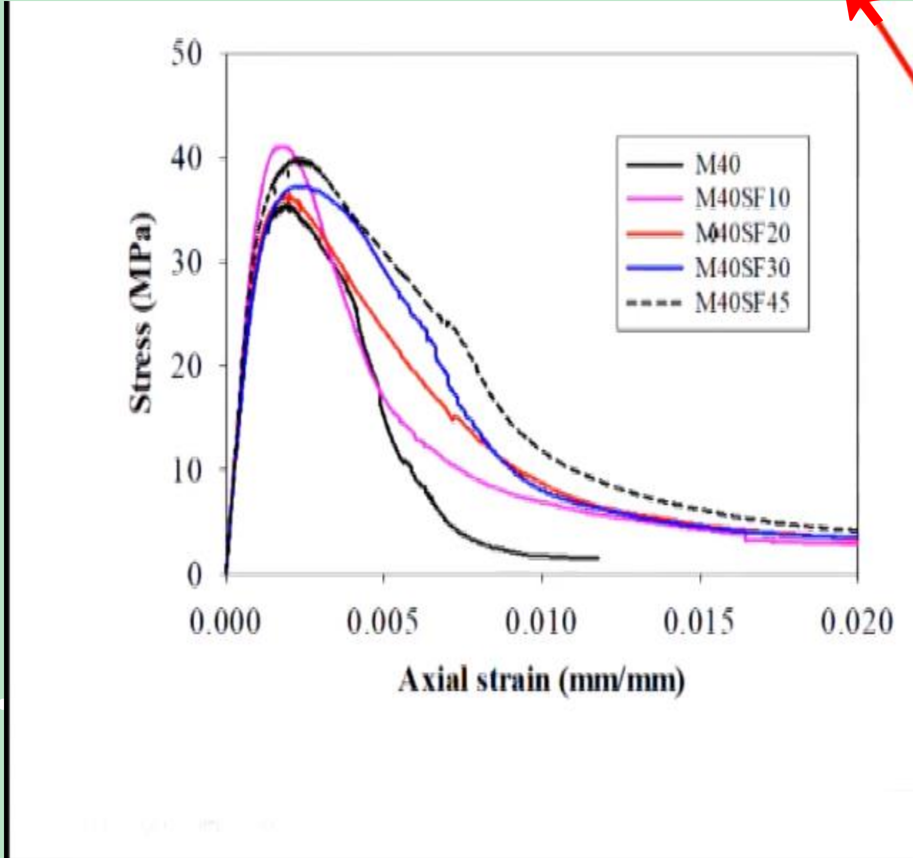
- Artificial crack is monitored using a clip gauge.
- During the test, we continuously observe how much the concrete expands.

Fibres aligned in the tensile stress direction may bring about very large increases in direct tensile strength. However, the increase in strength is much smaller for more or less randomly distributed fibres. Splitting-tension test of SFRC shows a similar result. Thus, adding fibres merely to increase the direct tensile strength is probably not worthwhile.


Load
Crack mouth opening displacement
Plain Concrete
FRC

- <u>Compressive Test –</u>

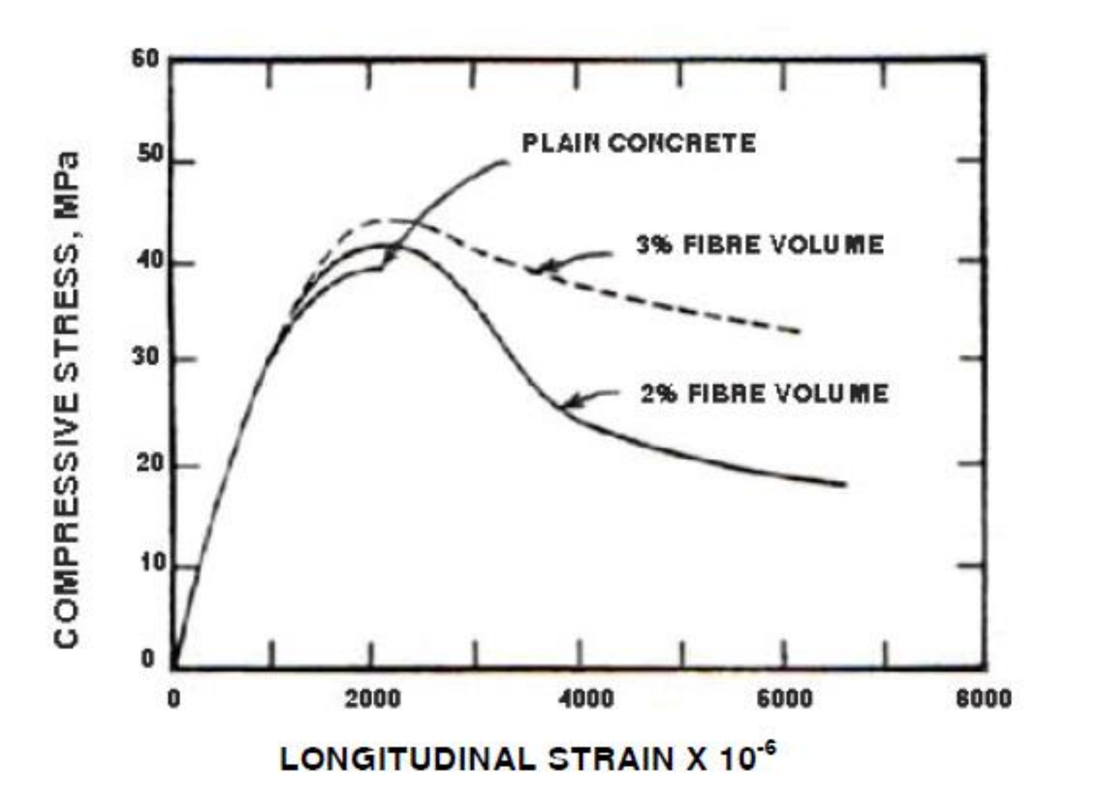
Chain- For measuring the expansion

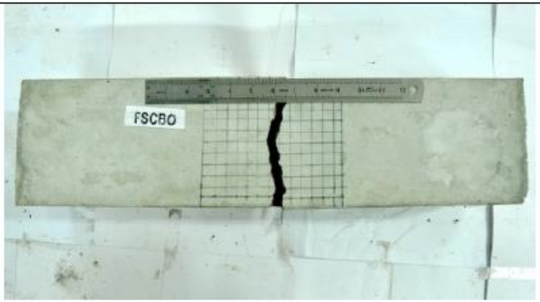


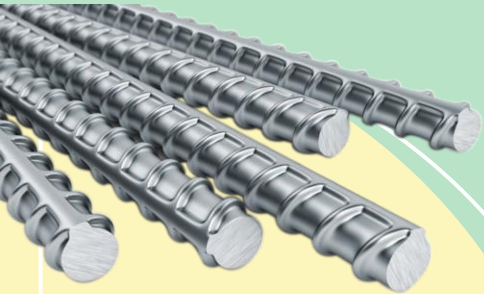
Gettu et al., 1996

- Post cracking compressive stress-strain curve changes substantially rather than the comp. strength curve.

- Fibres have little effect on compressive strength. However, the fibers do substantially increase the **post-cracking ductility** or **energy absorption** of the material.



Type of Specimen	Plain concrete	SFRC
Compression		
Tension		
Simply supported beam		



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STEEL REINFORCED CONCRETE

- Concrete has extremely good compressive strength but it’s very weak in tension.
- Steel rebars are used to compensate for the lack of tensile strength.
- Steel should always be placed in the tension zone.
- Main principle – ac

i) In a structural material, steel serves the purpose of bearing tensile stress.

ii) Concrete bears the main compressive forces

Note that – If only compressive loads are acting on the concrete surface, no need for reinforcement in it.

- Reinforcement costs 1/3rd of the total cost of the structure.

Active

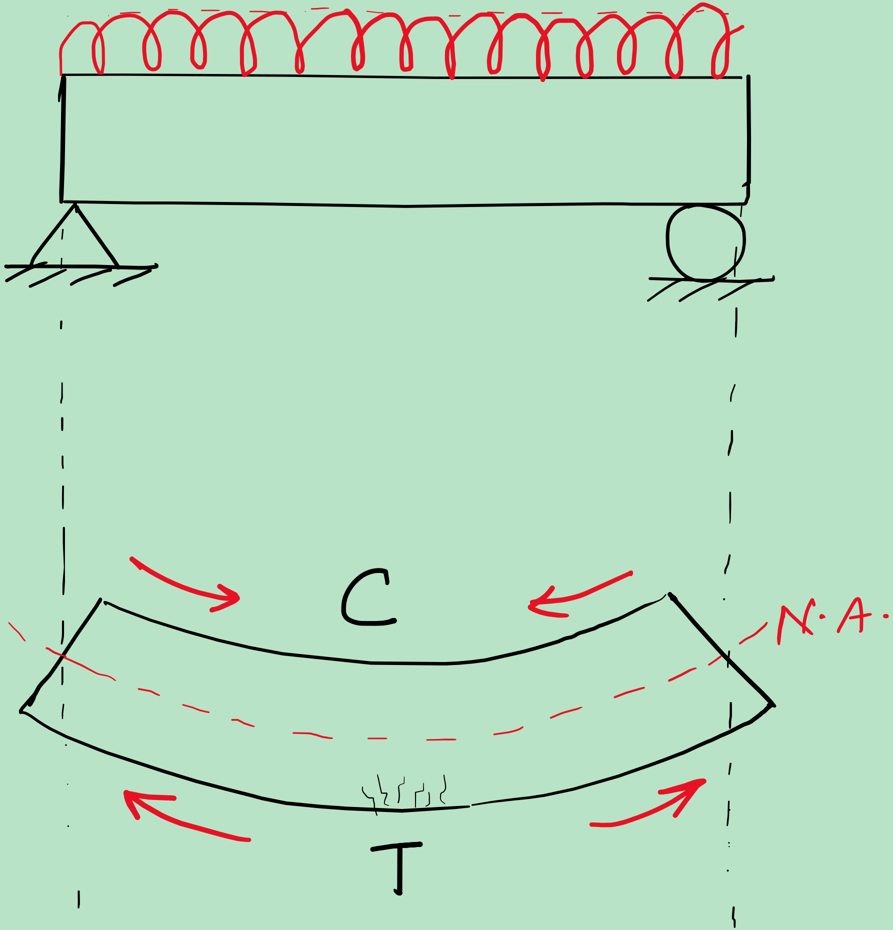
Used for prestressing

Passive

Subjected to stresses upon application of loads.

- Why steel?

  * Good tensile strength
  * Good bond with concrete
  * Coefficient of expansion same as concrete
  * Quality control possible during manufacture



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- Size of aggregates is restricted to 5 mm less than
  - Minimum distance between main bars
  - Minimum cover to reinforcement distance

- Admixtures should not increase the risk of corrosion of the reinforcement, which will result in decreased durability.

- Types of reinforcement –

  1) Mild steel &
  2) High strength deformed steel bars
  3) Hard drawn steel wire fabric
  4) Structural steel

<u>Reinforcement detailing as per IS Code –</u>

- **<u>Slab-</u>**

The main bars of the slabs should be 6-12 mm in diameter.
The minimum reinforcement in either direction of the slab must be 0.15 for mild steel and 0.12% for deformed bars of the cross-sectional area.

Maximum bar spacing of 460 mm in either direction of the slab. This was necessary to minimize the cracks due to temperature, shrinkage, and effective dispersion of concentrated loads.

- **<u>Beams-</u>**

Depending on the load, the depth of beams varies from 1/10 to 1/20 span.
Depth must be taken in multiples of 25 mm for sizes up to 500 mm and multiples of 500 mm for greater sizes.
The width of the section is selected from the range 0.33h to 0.50h.

- **<u>Longitudinal Reinforcement-</u>**

Deformed or plain bars of diameters of 10-40 mm are used.
To avoid congestion of reinforcement, the maximum area of the reinforcement is restricted to 4% of the cross-sectional area.

- **<u>Side face reinforcement-</u>**

Beam depth > 750 mm
Longitudinal bars installed on the sides of the beams not more than 300 mm apart.
The total area of these bars should be at least 1% of the cross-sectional area of the beam rib.

- **<u>Columns-</u>**

These can be square, rectangular, or circular in cross-section.
The lateral dimensions of columns up to 500 mm are taken in multiples of 50 mm and of those exceeding 500 mm in multiples of 100 mm.
A section less than 200 mm x 200 mm is not acceptable as a column.

- **<u>Longitudinal Reinforcement-</u>**

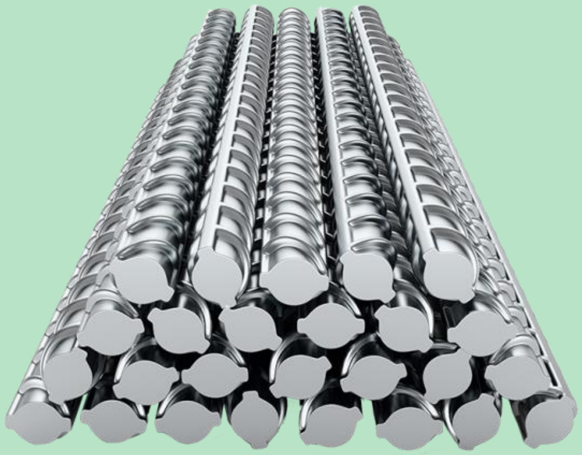
Consists of bars with diameters varying from 12 to 40 mm.

The minimum steel percentage of 6% to avoid congestion.

- **<u>Transverse Reinforcement-</u>**

Required in columns for both bucklings of main bars and resisting horizontal shear.

The thickness of the footings should be at least be 150 mm.



THANK YOU!