1. PRODUCT NAME

2. SUPPLIER

3. PRODUCT DESCRIPTION - S38 AND S50

4. TECHNICAL INFORMATION

5. MIXING STEEL FIBRES

6. PLACING AND FINISHING YOUR SFRC

7. TEN STEPS FOR QUALITY SLABS
3. PRODUCT DESCRIPTION - S38 AND S50
The fibres are made from Hard-Drawn low-carbon high tensile steel wire, and are Continuously Deformed conforming to the provisions of ASTM 820 Type 1.

Features
- Provides good impact, fatigue and shrinkage control in all grade concrete
- Easy to use at high doses in high performance pavements
- Is suited for hand and laser screeding and conventional finishing
- Is very good in post crack control (toughness)
- Its positive mechanical anchorage gives exceptional 3 dimensional post crack control
- Performs and sprays well in concrete applications
- Very economical

Estimating Data
The dose rate is dependent on the application however the minimum dose is 20kg/m³ and then it will increase in increments of 4kg/m³ accordingly

Typical Applications
- Pavements light duty to heavy impact, roads, roundabouts, paths, extrusions
- Toppings
- Precast
- Shotcrete
- Decorative stencil concrete
4. TECHNICAL INFORMATION

<table>
<thead>
<tr>
<th>FIBRE</th>
<th>General Purpose Fibre</th>
</tr>
</thead>
<tbody>
<tr>
<td>MINIMUM TENSILE STRENGTH</td>
<td>800MPa</td>
</tr>
<tr>
<td>FIBRE STRENGTH</td>
<td>38 mm</td>
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<tr>
<td>TOLERANCES</td>
<td>+ or - 5%</td>
</tr>
<tr>
<td>DESCRIPTION</td>
<td>Semi Circular in cross section</td>
</tr>
<tr>
<td>ANCHORAGE</td>
<td>Continuous Deformation</td>
</tr>
<tr>
<td>APPEARANCE</td>
<td>Bright and Clean wire</td>
</tr>
<tr>
<td>COMPLYING</td>
<td>ASTM A820 Type 1 &amp; AS1379-1991</td>
</tr>
</tbody>
</table>

The principal of all Fibrecon steel fibre reinforced concrete is to provide discrete, discontinuous reinforcement and effective crack control. Fibrecon Steel Fibres are available in various shapes and sizes to suit different applications.

Fibrecon works because unlike mesh reinforcing, the steel fibres reinforce in three dimensions throughout the entire concrete matrix.

The fibre functions to reinforce and restrain micro-cracking, essentially acting as “miniature reinforcing bars”. Thus the earlier the crack is intercepted and its growth inhibited, the lower the chance of it developing into a major flaw.

Fibrecon Steel Fibres improve the properties of concrete in many ways and is summarised below.

<table>
<thead>
<tr>
<th>PHYSICAL PROPERTY</th>
<th>BENEFICIAL EFFECT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Modulus of Rupture Concrete</td>
<td>1 to 2 x plain</td>
</tr>
<tr>
<td>Shear Strength Concrete</td>
<td>1.25 to 2 x plain</td>
</tr>
<tr>
<td>Torsional Strength Concrete</td>
<td>1.25 to 2 x plain</td>
</tr>
<tr>
<td>Impact Energy Absorption Concrete</td>
<td>2 to 15 x plain</td>
</tr>
<tr>
<td>Fatigue Resistant Concrete</td>
<td>1.2 to 2 x plain</td>
</tr>
<tr>
<td>Cavitation and Erosion Resistant Concrete</td>
<td>1 to 1.4 x plain</td>
</tr>
<tr>
<td>Restrained Shrinkage Crack Widths</td>
<td>Reduced Crack</td>
</tr>
<tr>
<td>Corrosion Resistance</td>
<td>No Cathodic Corrosion Observed</td>
</tr>
</tbody>
</table>
Slabs
• Eliminates Steel Mesh Reinforcement: Saving both materials and labour on site
• Increase speed of production on site
• Save time and reduce costs
• Have stronger and simpler joints
• Reduce spalling and maintenance with the high impact resistance of steel fibre concrete
• Ideal for Large Areas
• Ideal for High Load or High Impact Application
• Has been used for the last 15 years in industrial and Commercial applications with many millions of square metres successfully placed

Precast
• Eliminates Steel Mesh Reinforcement
• Dramatically increases production
• Reduce labour and reduce skilled needs
• Reinforces the edges and corners of precast products
• Reduced product damage and wastage as the fibres distribute completely through the concrete
• Fibrecon is approved for use under AS/NZ 1546.1:1998 Onsite Domestic Waste Water Treatment Units. Many manufacturers are using the fibrecon system. The Code allows for a reduction in concrete thickness with Fibrecon Steel Fibre System. Over 10,000 systems have been manufactured
• Can be used in Water Tanks, Pits, Head Walls, Risers, Troughs
• Fibrecon offers full engineering support if required

Shotcrete
• Increase safety by not having to replace reinforcing in difficult situations
• Save time and money on site by eliminating mesh
• Homogenous reinforcement to resist tensile forces in any point in the shotcrete layer
• Excellent corrosion resistance, no electrolytic corrosion in the shotcrete
• Minimisation of losses due to rebound and no loss of integrity due to shadowing from mesh
• Reduced material use as a thin layer of Steel Fibre reinforced Shotcrete can follow uneven contours with the need to achieve reinforcement cover
• Ideal for Mining and Tunnel applications, slope stabilisation, soil nailing, embankments, erosion control
**Bored Compression Piers**
This is an area where significant time and cost savings can be made by replacing the conventional shrinkage reinforcing cage with steel fibres. Many projects in Europe and Australia have been completed using this construction method.

**Toppings and Decking System Toppings**
Fibercon fibre reinforcement can be used in toppings to replace reinforcing fabric which is used for drying shrinkage and thermal crack control.

As Fibercon fibres do not have a specific cover requirement, they can provide both cost and time effectiveness in toppings for industrial and commercial projects. These savings are also available for proprietary concrete/metal deck systems.

**High Temperatures and Refractory Applications**
In high temperature applications Fibercon low carbon and stainless steel fibres can control potential cracking caused by thermal shock. Thermally induced spalling due to rapid change in temperature e.g. fire, is also reduced as the fibres improve the concrete matrix properties. Steel fibre reinforcing has specific applications in metalliferous manufacturing facilities. When manufactured with appropriate composition, Fibercon stainless steel fibres provide enhanced performance to refractory castable kiln lining segments, extending the time between maintenance shutdowns.

**Explosion and Impact Resistant Structures**
Fibercon fibres can be used on their own, or combined with other reinforcement to improve the energy absorbing capabilities and significantly increase spalling and impact resistance. Typical applications are in security products such as safes and vaults. Certain military applications will also benefit from the properties of steel fibre reinforced concrete.

Extreme duty industrial pavements are trafficked by tracked vehicles in mining, maintenance and military. Intense loading when the machine slews can gouge the concrete surface if the toughness is insufficient. High performance concrete containing high fibre dosage has been used to provide sufficient resistance to these vehicles.
**Chemical Containing Facilities**
For this application, prevention of chemical attack will be concrete quality and protective coating dependant. Improving the quality of the concrete by the addition of Fibercon fibres will protect against the likelihood of unacceptable structural degradation caused by cracking, which allows the ingress of aggressive agents, leading to further cracking caused by the expansive corrosion of reinforcing bars.

The simple fact is that Fibercon fibres are a discontinuous form of reinforcement which significantly reduces the risk of aggressive environments travelling through concrete.

**Mechanical Properties of Qubix Steel Fibres**
Fibercon steel fibres provide concrete with exceptional material properties.

Concrete is considered a brittle material, primarily due to its low tensile strength and low tensile strain capacity prior to fracture. In most applications, poor tensile performance of the concrete is compensated for by the inclusion of steel reinforcing bars in the tensile zones of a concrete structure.

Concrete can be modified to perform in a more ductile manner by adding a random distribution of Fibercon fibres through the concrete. This results in a composite system of brittle concrete and ductile Fibercon steel fibers to form an elastic-plastic system. The primary advantage of this system is the development of precrack and post-crack load carrying capacity in concrete elements rather than a catastrophic failure at the first fracture.

In the majority of slab ongrade and shotcrete applications, stresses in the concrete are being dynamically distributed. It is therefore difficult to determine a true stress pattern, or to place one or two layers of reinforcement at optimum locations when stresses are varying through structure.

The random distribution of Fibercon steel fibre reinforcement in the concrete ensures that crack-free stress accommodation occurs throughout the concrete. Microcracks from the larger aggregate that increase in size through propagation under increasing or cyclic stresses are subjected to a steel fibre barrier due to the composite system. Thus small cracks are intercepted before developing into larger cracks that might impair the performance of the structure.
Fibercon fibres are continuously deformed. The design and recommendation of each fibre type is appropriate to the end use being considered. Depending on the specification of the concrete and the dosage rate of Fibercon fibres, the various physical properties of concrete may be modified by the following degree.

**Shrinkage Cracking**

When concrete is subjected to a drying environment, shrinkage occurs and can be followed by cracking. The extent of shrinkage depends on many factors. If the concrete is restrained, tensile stresses that exceed the tensile strength of the concrete can develop and the concrete may crack.

The addition of Fibercon steel fibres has proven to considerably reduce the widths of cracks resulting from restrained shrinkage by distributing stresses at the crack and providing enhanced tensile strength to the uncracked portion of the concrete.

**Pull-Out**

In general, the greater the contact area between the fibre - matrix interface and the higher the resistance to pull-out generated by mechanical anchorage, the higher the load capacity of the concrete. Fibres in the Fibercon range have optimised designs to accommodate high fatigue or high stress applications.

**Load Deflection Behaviour or Toughness**

Load deflection curves are a standardised method of quantifying the energy a beam absorbs during it load induced flexural deflection. Toughness is calculated according to ASTM C1018, using load deflection data taken from third point loading.

As applied to test beams, deflection is measured at the midpoint using electronic dial gauges. The test is deflection rate controlled and a part of both the elastic and plastic regions of failure recorded. Unlike plain concrete, Fibercon fibre reinforced concrete does not fail in a brittle, catastrophic manner at the formation of the first crack with a clearly identifiable maximum load.

Well before signs of significant material distress are visible, the load deflection curve becomes non-linear, that is ductile behavior, and microscopic examination of the specimen reveals fine cracks. An increase in fibre concentration correlates with an increase in first crack strength.
Fatigue
When concrete is stressed in a cyclic manner, the propensity for the incipient microcracks at the larger aggregate/concrete matrix interface to propagate increases as the level of stress and the number of cycles increase. Plain concrete fails in fatigue at a lower stress level that the static tensile strength of the concrete. The fatigue behaviour can be expressed in many different forms, an example would be the endurance limit, expressed as a percentage of the modulus of plain concrete as applied to beams in the static flexural test.

For Fibercon fibre reinforced test beams, reinforced with 12kg and 24kg per cubic meter, there is an appreciable increase in this figure. The endurance limit is 71% for the mix with 20kg dosage and is 86% for the mix with 24kg dosage, whereas the endurance limit for plain concrete was 65%

This means that Fibercon fibres can be added in high fatigue components, such as ground slabs, to give extended life or a reduced section thickness.

Compressive Strength
A test sequence carried out to examine the effect on compressive strength of the addition of steel fibres showed that for the fibrous concrete with 12kg and 34kg per cubic metre dosages, the compressive strength decreased slightly.

For higher quantities of fibres (40kg and 50kg per cubic metre) there can be a discernible reduction in compressive strength. The decrease in strength is due to an increase in the water demand for workability casued by the wetted surface area demand of the fibres. If optimum mix proportions are maintained, the compressive strengths can be maintained.

It is also interesting to note the level of ductility evident during compression testing. Instead of a brittle failure the compression test cylinder will visibly yield and then progressively crush. This ductility can be progressive induced at low fibre dosage rates above 6kg per cubic metre.
**Durability**

The corrosion resistance of Fibercon fibres is governed by the same factors that influence corrosion resistance of conventionally reinforced concrete. As long as the matrix maintains its alkalinity and remains uncracked, deterioration is not likely to occur.

There is a specific advantage of Fibercon fibres over fabric or bar reinforcing in severe exposure environments. This is that the fibres, being unique and discrete, will not support classic galvanic corrosion cells, which are often the cause of corrosion and deterioration in fabric and bars. Hence Fibercon fibres can be used to advantage in extremely aggressive environments.

**Impact Strength**

The drop weight test used in an investigation is not a truly scientific test as it does not give accurate quantitative values for impact resistance. However, this is a very simple test that can give a comparative example of the performance in concrete. The impact strength increases considerably with the increase in fibre content. Compared to plain concrete, the increase in impact strengths were significant, a 12kg per cubic metre increased the impact strength 10 fold. The results prove that the addition of Fiberson fibres significantly increase impact resistance.

**Punch and Shear**

Fibercon high strength steel fibres have the ability, even at moderate addition levels, to improve punch and shear. Tests have been done to compare punch and shear behaviour of:-

- Plain Concrete
- Concrete reinforced with 2 layers of welded wire fabric
- Polypropylene Fibres
- Mill cut steel fibres
- High tensile deformed steel fibres

It was observed that the values of punch and shear are improved by the addition of relatively small quantities of steel fibres. No punching was observed, Here again, the stiffening and anchorage mechanism of deformed high tensile steel fibres are superior to any other fibre types or two layers of welded wire fabric.
5. MIXING STEEL FIBRES

Mixing at the batch plant
1. Add fibres prior to batching concrete
2. Add all fibres directly to the transit mixer from the box/bag or via the conveyor. The fibres must be added slowly, approximately 20 seconds per box/bag, with the bowl turning at minimum revolutions. Do not try to add via loading bins as they can jam the discharge chutes.
3. When fibre has been loaded, the bowl must be stopped until ready for batching
4. Batch concrete in normal manner
5. Adjust slump as normal or with super plasticiser
6. Mix at full mixing revolutions for not less than five minutes. The fibres should disperse evenly through the complete mix, incomplete mixing or balling should not be evident.

6. PLACING AND FINISHING YOUR SFRC

The final finished product in all concrete is what everyone looks at and it is important that it meets all requirements of the client. To achieve the result, care and good work practices must be used. Concrete mix design for your Fibercon Steel Fibre Slab must have satisfactory workability. Using correct concreting techniques will produce a fibre-free and high-quality finish.

The final appearance of your SFRC is controlled by a number of factors
1. Placement procedure
2. Finishing procedure
3. Ambient weather conditions
4. Curing

Placement
Placement of SFRC is not any great deal different from plain concrete the same important factors must be observed to get a good result.
1. Good, careful vibration, constant level checking and flat screeding will produce the first stage of a quality slab. Like plain concrete, SFRC can be placed either manually or mechanically (this paper mainly pertains to manual placement)
**Finishing**

This is one area that will directly reflect the finishing methods used. When finishng SFRC it is now known that to pass the bull float twice will initially help to cover any fibre on surface. Next you must adopt the “FLAT MEANS FLAT” policy when using any trowel or troweling machine. Like conventional concrete all passes of your trowelling machine must be done with blades at minimum pitch to ensure a flat “waveless” floor. This applies to hand work also. When using a panning system the machine must be used in a correct overlap pattern to ensure “waves” are not created. The first pass (known as breaking) is the most critical pass with the machine.

Breaking the slab at the earliest time possible, when machines can be placed on concrete without sinking is very important. This begins the process of pushing your fibre and large aggregate down while drawing water from the bottom of the slab up through the concrete enabling a slower consistent setting process at the surface.

As the concrete sets, each pass of the machine gradually brings the finer materials up and pushes the larger materials down.

The final stage of finishing is what you will see forever and therefore is important that it is done correctly.

When the concrete surface has reached the last stage, a fine paste of 0.5 to 2mm is present. Now the final trowelling will give a very smooth finish which can be either left as is broomed, textured or burnished. Burnishing (burning) your slab is often required and will give a very hard, glazed surface that appears blackened. Burnishing your slab will extend the life of your concrete.

To “burn” the slab the trowelling machine must be placed on the slab after final steel trowel and used at moderate to high speeds once concrete has 99% set. Blade angle should be at the lowest pitch possible.

Many concreters know that if they wind their troweling machine blades up that they will drag the surface rather than spread and flatten however they still do so because it enables one man to cover a larger area (but not at the same quality).
When using SFRC if you wind the blades up you will drag fibres to the surface rather than cover them with paste below the surface therefore leaving them exposed on the surface. If correct methods are used no problems will occur.

One common problem is that people like to blame products, tools, machines or anything rather than admit that the techniques used may be wrong or human error occurred. Again I would like to emphasize that you cant cheat concrete placement and finishing with SFRC like plain concrete because your finished product will reflect the technique and processes used.

**Edges - “Run in your edges early”**
To get good edge finish, you will need to rough in the edges earlier than may be normal, this pushes any fibres down and you have the opportunity to pull any out that may be obstructing tooling a edge. Once you have done this, nothing else changes, normal finishing techniques work.

**Harsh Weather**
In Australia, New Zealand and Islands ambient conditions play a large role in placement and finishing of all concrete. Briefly, you should adopt a rule where if it is dry, hot and windy you must use Aliphatic Alcohol to prevent early flash setting on surface (crusting). If the conditions also affect placement I recommend the use of a plasticiser or mid range water reducer to give slump control during placement allowing 100 - 150mm slumps without affecting concrete strength (w/c ratio).

These products are also often used when high strength concrete is used to control plastic shrinkage. The use of these products should only be done after consulting the manufacturer and your concrete supplier.

**Curing**
One of the aspects of concrete that can make or break you is curing. Curing must be done on all concrete for minimum 7 days after finishing enabling the concrete to reach its designed strength and surface hardness and minimize curing. In recent times often it is neglected resulting in a lower quality concrete with low wear resistance and often causing premature drying shrinkage cracking. SFRC is no different, it also needs to be cured to obtain optimum performance. Many papers have been written on curing and all come to the same conclusion, that concrete wherever possible must be cured to produce design performance.
**Summation**
When using SFRC you must take into consideration your conditions and clients' requirements to ensure that the correct demands for the project are met, and you can produce the required finish of your SFRC.

7. **TEN STEPS FOR QUALITY SLABS**
1. No water to be added at site, get workable concrete to start
2. Extra bars at re-entrant corners, penetrations and trims
3. Rectify spots in accordance with Engineers Specification
4. Prepare subgrade in accordance with Engineers Specification
5. Vibrate and compact concrete during placement
6. Get on to finish a little later and keep trowelling blades horizontal
7. Saw cutting needs to be 40% slab depth
8. Saw cut and dowel layout should be as per engineers specification or maximum 6m x 6m with dowels as necessary
9. Saw cutting should be an early entry soft cut; otherwise wet cut should be carried out within 18 to 24 hours of pouring
10. Attention to detail should be given to finishing and curing is required