Steel Fibres on Surface

This Flooring Technical Note considers the appearance of steel fibres on the surface of concrete slabs. It focuses on what surface fibres to expect and the casting and finishing techniques to help reduce their occurrence.

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Introduction

As SFRC (Steel Fibre Reinforcement Concrete) is a composite material, steel fibres are mixed throughout the entire concrete mix, meaning that they will be present from the top to the bottom of a slab. Therefore, concrete cover, associated with traditional reinforcement methods, is not achievable. As a consequence, some surface fibres can be expected, but casting and finishing techniques do exist to help reduce their occurrence significantly.

Commentary

1) Fibre Count

Whilst SFRC can be described in generic terms, the dosage and type of fibre used has a significant influence on the likely number of surface fibres. The higher the aspect ratio (length/diameter) of a steel fibre type, the higher the fibre count per kilo. A small difference in steel fibre diameter can make a huge difference in the amount of fibres.

For example, comparing rows 1 and 2 in the table below, whilst the diameter may decrease by just 15% (from 1.05mm to 0.9mm), the fibre count will increase by around 35%.

	Fibre Length (mm)	Wire Diameter (mm)	Approximate Aspect Ratio (l/d)	Fibre Count Per Kilo
1	60	1.05	57	2339
2	60	0.90	67	3183
3	60	0.75	80	4584

Looking at rows 1 and 3, the diameter decreases by 33%, but the fibre count increases by 95%. So, whilst the industry may discuss ‘a 60mm fibre’ in generic terms, a change in diameter can produce anything up to double the reinforcement. This can have a large influence on the occurrence of surface fibres. The simple solution would appear at first to be to use a low aspect ratio fibre to get as few surface fibres as possible, however, it should be noted that the higher the aspect ratio, the higher the performance of the SFRC. With a large emphasis in the UK being on the use of steel fibres in high performance ‘jointless’ floors and floors suspended on piles, fibre types on the higher end of the scale are likely to be used. Low aspect ratio (larger diameter) steel fibres are often not suitable for floors of this type, even at high dosages.

2) Orientation

It should be noted that surface fibres will predominantly be laid horizontally, rather than vertically or diagonally, especially when a bull float is used shortly after the initial screeding process. When the finished floor is trafficked, these horizontal fibres

will eventually become dislodged from the surface, and leave a 50-60mm long, 1mm deep crater, on average. For this reason, unless there are areas of severe surface fibre numbers, these 'fossils' should be left as they are, and unrepaired.

Typical surface fibres 'fossils' left once the floor has been trafficked

3) Consequences

As most fibres used in industrial flooring are made from cold drawn, mild (uncoated) steel wire, any surface fibres will corrode if exposed to conditions similar to those experienced externally. However, as most buildings protect the floor from external weather conditions, and have a constant ambient temperature, corrosion of surface fibres in a warehouse is highly unlikely. On an external yard subject to a brush finish, however, corrosion can be expected shortly after casting.

As steel fibres are a 3-dimensional type of reinforcement, one individual fibre is not physically connected to the next in its direct vicinity. For this reason, a single corroded surface fibre will not affect the other fibres located beneath the floor surface, and hence will not adversely affect the structural integrity of a floor slab. For this reason, surface fibres should be considered an aesthetic issue only.

4) Required floor finish

It should be noted that in some cases, what may initially seem an excessive number of surface fibres may actually be deemed acceptable and fit for purpose, in-line with the future usage of a slab. For example, where a floor is to be covered by terrazzo tiling or similar, surface fibres should not be considered a problem as a specialist will be required to provide a skip-float finish only. As a powerfloat finish is rarely used in these applications (and hence a dry-shake topping will not be applied) then more frequent occurrence of surface fibres should be deemed acceptable and of no adverse consequence.

A brush finish inside a building should be avoided when using SFRC, as this technique has a tendency to drag more fibres to the surface than may be deemed acceptable.

5) Mix Design & other materials

Dry-shake topping materials (usually a blend of cement and quartz aggregates) have a dual purpose; to increase floor abrasion resistance, and to supress surface fibres.

The occurrence of surface fibres can be reduced by using a concrete mix design with a higher than normal fine aggregate content. However, a trade-off is required, as an overly-sanded mix can in some cases be the cause of delamination of newly laid dry shake toppings.

The concrete mix must have a sufficient fines content in order to remain cohesive, but this fines content should take into account the extra fines contained in the applied dry shake.

Existing guidelines

A standard for fibres on the surface does exist, a Belgian guideline called TV204. Although its relevance in today's advanced flooring market with improved finishing techniques etc. could be questioned, its content can be summarised as follows:

Type of finishing	Good	Reasonable
With wearing surface	x < 3	3<= x < 6
Without wearing surface	x < 6	6<=x < 10

x= the amount of visible fibres at the surface per m²

To determine the amount of fibres/m², a number of 100m² squares are marked on the floor surface. The number of squares that have to be reviewed is 5 if the floor is smaller than 10,000m², and 10 if the surface is greater than 10,000m².

In each square, one determines 5 arbitrary 1m² areas, and counts the number of visible fibres at the surface contained within. The average/mean is determined, and compared with the table above. For example, a floor of 9,000m² would require 5 squares of 100m² to be taken.

In each square, 5 smaller squares of 1m² are taken, therefore 25 values are determined. The average of those 25 values is then calculated, and compared with the table.

Summary

When steel fibres were used for the first time in the UK in the early 90s, contractors were inexperienced and finishing techniques were not specifically tailored to the use of SFRC. For these reasons, some projects were completed with surfaces that would nowadays be deemed of a poor standard. However, with increased specialist experience gained over the years, the introduction of dry-shake toppings and associated mechanical plant, and state-of-the-art developments in steel fibre technology (allowing lower dosages of high performing fibres to be used), ACIFC contractor members are now largely expert in the casting and finishing of SFRC concrete, making them able to provide working surfaces practically free from unwanted fibres.

It should be noted that, as a cubic metre of concrete may contain anything between 50,000 and 200,000 individual fibres, a 100% fibre-free surface is unachievable over large areas, and the occurrence of small numbers of visible steel fibres should be both anticipated and accepted by the client, even when employing the most experienced specialists. However, employing an inexperienced contractor can result in poorer quality surface finishes being achieved.

Surface fibres, whilst aesthetically displeasing, cause no structural issues and resulting surface blemishes should be considered as only minor.

Further Reading

The Concrete Society Technical Report 34 Fourth Edition - *'Concrete Industrial Ground Floors; A guide to design and construction'* (2013)

The Association of Concrete Industrial Flooring Contractors – *'Steel Fibre Reinforced Concrete Industrial Ground Floors; An Introductory Guide'* (1999)

The Association of Concrete Industrial Flooring Contractors – *'Dry Shake Finishes for Concrete Industrial Floors; An Introductory Guide'* (2001)

Belgian FOS Guideline TV204

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