# TECHNICAL NOTE

AEFAC
Australian Engineered Fasteners and Anchors Council

AEFAC – TN16

# DESIGN OF FASTENERS IN STEEL FIBER REINFORCED CONCRETE

Ver. 1.0
September 2025

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## Revision Sheet

| Revision Number | Clause/ Figure/ Table | Revision type | Issued on |
|---|---|---|---|
| 0 | | Initial release | September 2025 |

# 1. Scope

Steel Fibre Reinforced Concrete (SFRC) is a composite material consisting of discrete steel fibres uniformly dispersed throughout the concrete matrix. The current version of AS 5216[1] does not provide specific provisions for the design of fasteners installed in SFRC. Consequently, designers often rely on proprietary information and technical guidance from manufacturers and suppliers.

The recommendations provided in this Technical Note is applicable to SFRC with a dosage of 30kg/m3 to 80kg/m3.

This technical note presents general recommendations for the design of fasteners intended for use in SFRC. The guidance provided herein is intended to support informed engineering judgment and does not replace the manufacturer's installation instructions or the project-specific technical advice from the manufacturer or supplier.

# 2. Terminology

The following terms and definitions are used throughout this Technical Note. For further clarification and additional terminology, reference should be made to AS 5216[1] and the AEFAC Anchor Dictionary[2].

*Aspect ratio*: Ratio of fiber length to fiber diameter.

*Balling*: phenomenon where steel fibres clump or entangle together during mixing, forming dense fiber balls or clumps instead of being evenly distributed throughout the concrete matrix.

*Dosage*: quantity of steel fibers in kilograms per cubic meter (kg/m3)

*Steel fibre reinforced concrete*: A composite material consisting of concrete mixed with steel fibres.

# 3. Notation

| | | |
|---|---|---|
| $d_f$ | = | Fiber diameter |
| $f'_c$ | = | Characteristic compressive strength of concrete measured via cylinder tests at 28 days |
| $h_{ef}$ | = | Effective embedment depth of a fastener |
| $k_1$ | = | Parameter related to the characteristic strength of a single fastener to concrete cone failure under tensile loading ($k_{ucr,N}$ for uncracked concrete) |
| $k_{ucr,N}$ | = | Parameter relating to uncracked concrete loaded in tension |

$L_f$ = Fiber length

$N^0_{Rk,c}$ = Reference characteristic tensile strength of a fastener to concrete cone failure

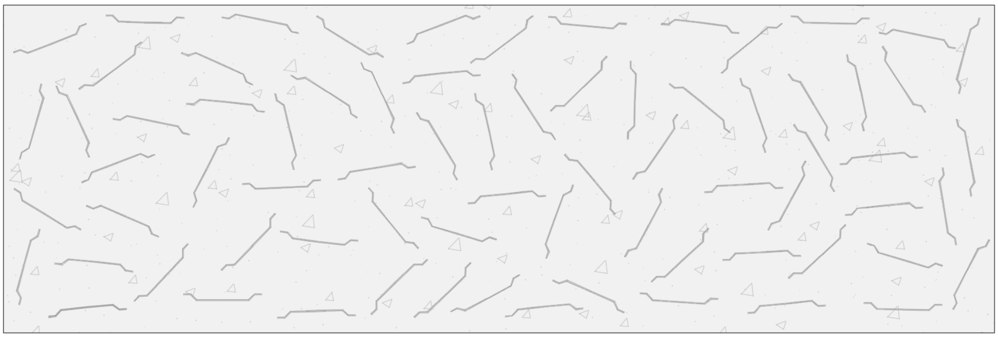
$\psi_{fiber}$ = Parameter accounting for the influence of steel fibers (refer *Table* 1)

$\rho_{fiber}$ = Dosage of fiber in kg/m$^3$

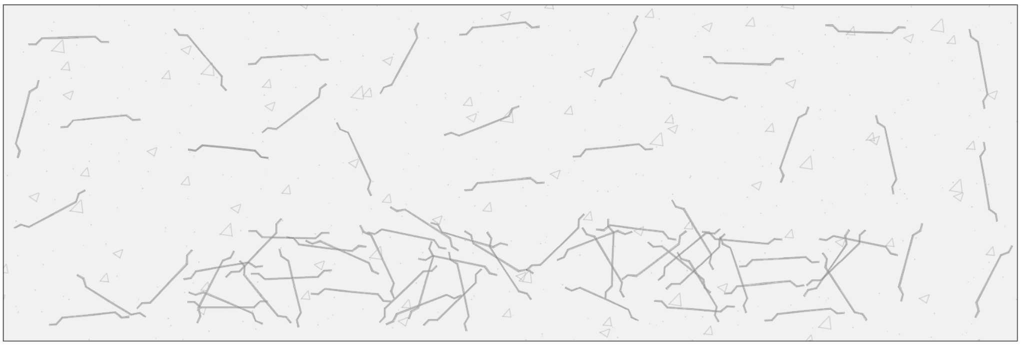
## 4. General

### 4.1. Steel-fiber reinforced concrete

Steel fibre reinforced concrete (SFRC) is a composite material consisting of concrete mixed with steel fibres conforming to ISO 13270[3] or EN 14889 [4]. The fibers should be uniformly distributed throughout the concrete matrix without balling (Figure 1). In addition to handling, balling is likely affected by the fiber aspect ratio (Lf/df) and fiber dosage.



(a)



(b)

*Figure 1 (a) Uniform distribution of steel fibers and (b) Distribution of fibers with balling*

There are two main categories of steel fibers: (i) Undeformed fibers and (ii) Deformed fibers

### *4.1.1. Undeformed fiber:*

Undeformed steel fibres are straight steel elements with a constant cross-sectional profile along their entire length without any form of mechanical anchorage, such as hooks, indentations, or surface deformations. These fibres are generally circular in cross-section and provide reinforcement primarily through frictional and adhesive bonding with the concrete matrix.

### *4.1.2. Deformed steel fibres:*

Deformed steel fibres are characterised by intentional surface modifications or end formations that enhance mechanical interlock and bond strength with the concrete.

## 4.2. Installation of fasteners in SFRC

For cast-in headed fasteners, the installation procedure in SFRC is generally consistent with that in plain concrete. Fasteners should be securely fixed in their intended positions before concrete placement to ensure proper embedment and alignment.

For post-installed fasteners, drilling into hardened SFRC shall be carried out prior to installation. Drilling in SFRC may require additional time compared to plain concrete due to the presence of steel fibres, which may deform plastically or displaced during the drilling process [5]. Following drilling, the hole shall be cleaned in accordance with the manufacturer's installation instructions. Due to the presence of steel fibres, effective cleaning may be challenging, and a higher air pressure may be required to ensure complete removal of fibre fragments and concrete dust from the drilled hole (Figure 2). The air used for blowing must be clean and free of oil. After the hole has been cleaned, the fasteners shall be installed in accordance with the manufacturer's installation instructions or the technical guidance provided by the manufacturer or supplier.

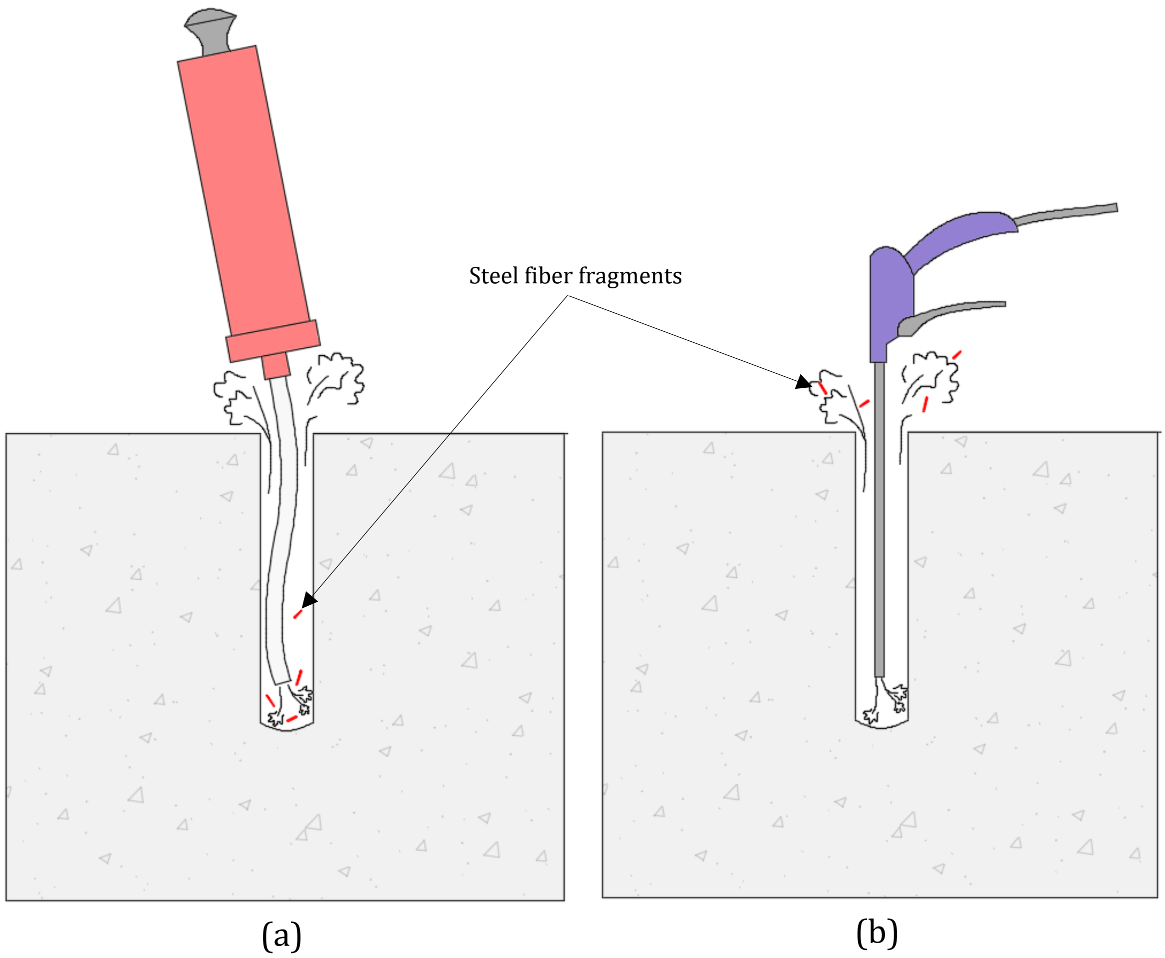



*Figure 2 Fiber fragments (a) inside the hole at low air pressure and (b) removed at high air pressure*

## 5. Design of fasteners in SFRC for tension

### 5.1. General

The ultimate strength of the fastener in SFRC shall be verified considering all possible modes of failure.

### 5.2. Steel failure

Steel failure is independent of the concrete member and the tensile capacity of fastener shall be calculated according to AS 5216 or the product prequalification report.

## 5.3. Concrete cone failure

The characteristic strength of a fastener in SFRC, remote from the effect of adjacent fasteners or edges of the concrete base, shall be calculated as follows:

$$N^0_{Rk,c}=\psi_{fiber}\, k_1\sqrt{f'_c}\, h_{ef}^{1.5}$$

Where,

$N^0_{Rk,c}$ = Reference characteristic strength of a fastener, remote from the effects of adjacent fasteners or edges of the concrete member.

$f'_c$ = Characteristic compressive strength of concrete measured via cylinder tests at 28 days

$h_{ef}$ = Effective embedment depth of a fastener

$k_1$ = Parameter related to the characteristic strength of a single fastener to concrete cone failure under tensile loading ($k_{ucr,N}$ for uncracked concrete)
For post-installed fasteners $k_{ucr,N}$=11.0
For cast-in headed fastener $k_{ucr,N}$=12.7

$\psi_{fiber}$ = Parameter accounting for the influence of steel fibers (*Table* 1)

*Table 1 Value of $\psi_{fiber}$ for different types of fasteners*

| Fastener Type | $\psi_{fiber}$ | Condition |
|---|---|---|
| Headed and Chemical [7] | $\rho_{fiber}/300+1\leq 1.25$ | For, $h_{ef}/L_f \geq 1.7$, $30kg/m^3 \leq \rho_{fiber} \leq 80kg/m^3$ |
| Others | 1 | |

Where, $\rho_{fiber}$ is the dosage of fiber in $kg/m^3$ and $L_f$ is the fiber length.

## 5.4. Pullout failure

The pullout resistance of fasteners is product dependent and is not significantly affected by steel fibers. The characteristic tensile strength of a fastener against pullout failure ($N_{Rk,p}$) shall be determined from Appendix A of AS 5216 or from the product prequalification document.

## 6. Acknowledgements

The Australian Engineered Fasteners and Anchors Council (AEFAC) acknowledges the support provided by SmartCrete CRC in the development of this Technical Note.

## 7. References

[1] Standards Australia, AS 5216 (2021): Design of post-installed and cast-in fastenings in concrete, SAI Global, Sydney

[2] AEFAC, Technical Note, "AEFAC Anchor Dictionary," Australian Engineered Fasteners and Anchors Council. www.aefac.org.au.

[3] ISO. (2013). ISO13270:2013 Steel fibres for concrete — Definitions and specifications.

[4] EN 14889 Fibres for concrete- Part 1: Steel fibres- Definitions, specifications and conformity. (2006).

[5] Spyridis, P., Walter, L., Biermann, D., & Dreier, J. (2022). Effects of steel fibres on hammer drilling in concrete for the installation of post-installed anchors. Journal of Building Engineering, 52, 104395. https://doi.org/10.1016/j.jobe.2022.104395

[6] Standards Australia. (2015). Prefabricated concrete elements Part 1: General requirements. SAI Global, Sydney.

[7] Tóth, M., Bokor, B., & Sharma, A. (2019). Anchorage in steel fiber reinforced concrete – concept, experimental evidence and design recommendations for concrete cone and concrete edge breakout failure modes. Engineering Structures, 181, 60–75. https://doi.org/10.1016/j.engstruct.2018.12.007

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