TECHNICAL NOTE

AEFAC
Australian Engineered Fasteners and Anchors Council

AEFAC – TN17

DESIGN OF FASTENERS IN HIGH STRENGTH CONCRETE

Ver. 1.0
September 2025

Table of Contents

Revision Sheet

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

1. Scope

High-strength concrete (HSC) is a type of concrete characterized by its higher compressive strength, typically exceeding 50MPa. The current version of AS 5216 allows fastener to be installed in concrete with a characteristic compressive strength of 12 MPa to 90 MPa. For design purposes, the compressive strength is limited to 60 MPa. For concrete with compressive strength higher than 90MPa, designers have to rely on proprietary information and technical guidance from manufacturers and suppliers.

The recommendations provided in this Technical Note is applicable to normal weight concrete with charecteristic compressive strength up to 100MPa.

This technical note presents general recommendations for the design of fasteners intended for use in HSC. 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].

Admixture: A material other than water, aggregates and cementitious materials, used as an ingredient in the concrete mix, and added in controlled amounts before or during the mixing process, to produce some desired modification to the concrete properties.

Supplementary cementitious material: Materials such as fly ash, slag, or silica fume that are used in combination with Portland cement to enhance concrete properties like strength, durability, and sustainability by participating in the hydration reaction or acting as fillers.

Normal-Strength Concrete (NSC): Concrete with a compressive strength typically ranging from 20 MPa to 50 MPa, commonly used in general construction applications where high strength or special performance is not required.

High-Strength Concrete (HSC): Concrete with a compressive strength higher than normal-strength concrete.

Workability: The ease with which freshly mixed concrete can be mixed, placed, compacted, and finished without segregation.

Cone angle: The angle of the failure cone (with respect to horizontal) that develops in concrete when a fastener is subjected to tensile loading.

3. Notation

$c_{cr,N}$	=	Edge distance of a single fastener required to ensure the characteristic strength of the fastener is achieved when loaded in tension
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
$N^0_{Rk,c}$	=	Reference characteristic tensile strength of a fastener to concrete cone failure
$N_{Rk,p}$	=	Characteristic tensile strength of a fastener to pull-out failure
$s_{cr,N}$	=	Spacing that is required for a fastener to develop its characteristic tensile strength

4. General

4.1. High-Strength Concrete

High-Strength Concrete (HSC) is a type of concrete that exhibits a significantly higher compressive strength than normal-strength concrete (NSC), typically exceeding 50 MPa. HSC is generally produced using low water-to-cement ratios, high-quality aggregates, supplementary cementitious materials, and in some cases, chemical admixtures to achieve the desired strength and workability.

4.2. Installation of fasteners in HSC

For cast-in headed fasteners, the installation procedure in HSC 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 HSC shall be carried out prior to installation. Due to the increased compressive strength of HSC, drilling may require additional time and effort compared to normal-strength concrete, as higher resistance to penetration can be expected. Upon completion of drilling, the hole shall be cleaned thoroughly in accordance with the fastener manufacturer's installation instruction to ensure proper bond and performance. Following cleaning, fasteners shall be installed strictly in accordance with the manufacturer's installation instructions or relevant technical documentation provided by the manufacturer or supplier.

5. Design of fasteners in HSC for tension

5.1. General

The ultimate strength of the fastener in HSC 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 and shall be calculated according to AS 5216 or the product prequalification report.

5.3. Concrete cone failure

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

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

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 (limited to 60 MPa)
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

Geometric effect of edge distance and spacing:

The spacing of headed and post-installed fasteners to ensure the transmission of the characteristic tensile strength of a single fastener ($s_{cr,N}$) shall be taken according to AS5216 as:

$$s_{cr,N} = 2c_{cr,N} = 3h_{ef}$$

Where, $c_{cr,N}$= characteristic edge distance determined in accordance with Appendix A of AS5216

Note: The Concrete Capacity Method considers the slope of the cone (cone angle) to be 35 degrees with the horizontal, resulting in a cone diameter of $3h_{ef}$. For higher compressive strength, the cone angle may become flatter, and the cone diameter could be larger (up to about $5h_{ef}$ at 100 MPa). This may require larger spacing of fasteners and larger edge distance.

5.4. Pullout failure

The pullout resistance of fasteners is product-dependent and is affected by the high strength of concrete. The characteristic tensile strength of a fastener against pullout failure ($N_{Rk,p}$) shall be determined from Appendix A of AS 5216.

Note: In the absence of additional test data, the pullout capacity of fasteners installed in high-strength concrete (with a characteristic compressive strength exceeding 50 MPa) may be assumed to be equivalent to that in concrete with a compressive strength of 50 MPa.

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: Design of post-installed and cast-in fastenings in concrete, SAI Global, Sydney, 2021.

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

AEFAC
Australian Engineered
Fasteners and Anchors Council

www.aefac.org.au