Complying with the Revised AS 5216:2021 Fastener Standard

A Focus on Appendix F: Design of Post-Installed Fasteners Under Seismic Actions

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INTRODUCTION

Fasteners have a direct impact on many aspects of a wall or ceiling system, including strength, durability, performance in different environments, and even maintenance over the assembly's lifetime. Accordingly, it is essential for professionals to understand the regulatory requirements governing the design and installation of fasteners to ensure the construction of safe and functional building structures.

In 2021, the new version of AS 5216:2021 "Design of post-installed and cast-in fastenings in concrete" was published. Superseding the 2018 edition of the same standard, AS 5216:2021 imposes new provisions on the design of fasteners for fastening to concrete that will have significant implications for compliance across the industry.

AS 5216:2021, like its 2018 counterpart, states that fasteners used in safety-critical applications are deemed to comply if they have undergone testing by a Registered Testing Authority (in accordance with EAD 330232) and successfully completed the process to receive a European Technical Assessment (ETA) document. Notably, the revised standard provides a consistent approach for the design and prequalification of fasteners under four new topics:

- Design of post-installed reinforcing bar connections;
- Design of anchor channel loaded in shear in the longitudinal direction;
- Design of redundant non-structural fasteners; and
- Design of post-installed fasteners under seismic actions.

Architects, designers and building professionals need to have a thorough understanding of the changes implemented by the revised AS 5216:2021. These new provisions are not a building-by-building option, but rather requirements that need to be factored in at all stages of the building process to ensure compliance.

In this whitepaper, we focus on Appendix F in AS 5216:2021, which sets out requirements for the design of post-installed fasteners under seismic action, and its impact on new building projects and professionals in the industry. Appendix F introduces fastener seismic performance categories C1 and C2.

SCOPE AND APPLICATION OF AS 5216:2021

AS 5216 is the Australian Standard for the "Design of post-installed and cast-in fastenings in concrete". The Standard sets out the minimum requirements for the selection, design, and assessment of cast-in anchor channels and post-installed fasteners for connecting steel to concrete.

The scope of AS 5216 relates to the design of fastenings to concrete in "safety-critical" applications. "Safety-critical" applications are those where failure could lead to the structure collapsing or partially collapsing, endangering human life and/or resulting in significant financial loss. Whether or not a particular application is safety critical is for the responsible engineer to decide, but where in doubt, it is generally advisable to specify fixing products that comply with the Standard.

The Australian Building Codes Board, which publishes the National Construction Code (NCC) has approved AS 5216:2021. The revised Standard is a primary reference in the NCC 2022 thus superseding all references to AS 5216:2018. The relevant clauses that mention AS 5216:2021 are Clause B1D4 in NCC 2022 Vol. 1 and Clause 2.2.4 in NCC 2022 Vol. 2.

"These new provisions are not a building-by-building option, but rather requirements that need to be factored in at all stages of the building process to ensure compliance."

NEW APPENDIX F AND WHAT IT MEANS FOR COMPLIANCE

What are the requirements in Appendix F?

Under Appendix F of AS 5216:2021, fasteners used to resist seismic actions need to meet all relevant requirements for non-seismic actions and be prequalified for cracked concrete and where necessary for seismic actions.[1] The seismic performance categories specify the level of prequalification for seismic applications. Prequalification documents outline the fasteners' suitability in the cracked concrete and seismic performance categories.[2]

How to determine seismic performance category

The seismic performance category of the fasteners needed for safety-critical applications within a project can be determined using the two tables in Appendix F, namely Tables F.3.1 and F.3.2.

Table F.3.1 provides the mandatory minimum seismic performance categories for fasteners based on expected crack widths of the concrete substrate under seismic conditions. Only a competent engineer who conducts a special study of the concrete and location in question can determine the concrete crack width under a design earthquake.

Table 1. Minimum required seismic performance categories for fasteners (Table F.3.1 of AS 5216:2021).

CRACK WIDTH UNDER DESIGN EARTHQUAKE[a]	FASTENER SEISMIC PERFORMANCE CATEGORY
$w \leq 0.3$mm	Seismic prequalification is not required.[b]
$w \leq 0.5$mm	C1
$w \leq 0.8$mm	C2
$w > 0.8$mm (Plastic hinge region)	Not Covered by AS 5216
[a] Crack width size is based off pre-qualified requirements of EOTA TR049.	
[b] Seismic design of the fastener is required but fastener does not require seismic prequalificationn	

If it is not practical or feasible to conduct detailed analysis of the concrete substrate to examine the expected crack conditions, Table F.3.2 must be used. Table F.3.2 provides an alternative simplified approach for determining the minimum recommended seismic performance category if the crack widths provided in Table F.3.1 cannot be readily confirmed.

The Table F.3.2 approach determines a recommended seismic performance category based on building importance level (BIL), site sub-soil class and site hazard factor.

Table 2. Minimum recommended seismic performance categories for fasteners (Table F.3.2 of AS 5216:2021).

Importance level	(KpZ) FOR SITE SUB-SOIL CLASS					Sesmic Performance Category
	Ee	De	Ce	Be	Ae	
2	N/A	N/A	N/A	≤ 0.10	≤ 0.12	Seismic prequalification is not required
	N/A	0.08	≤ 0.12	> 0.10 to ≤ 0.18	≤ 0.12 to ≤ 0.22	C1
	≥ 0.08	> 0.08	> 0.12	> 0.18	> 0.22	C2
3	N/A	0.08	≤ 0.12	≤ 0.18	≤ 0.22	C1
	≤ 0.08	> 0.08	> 0.12	> 0.18	> 0.22	C2
4	> 0.08					C2

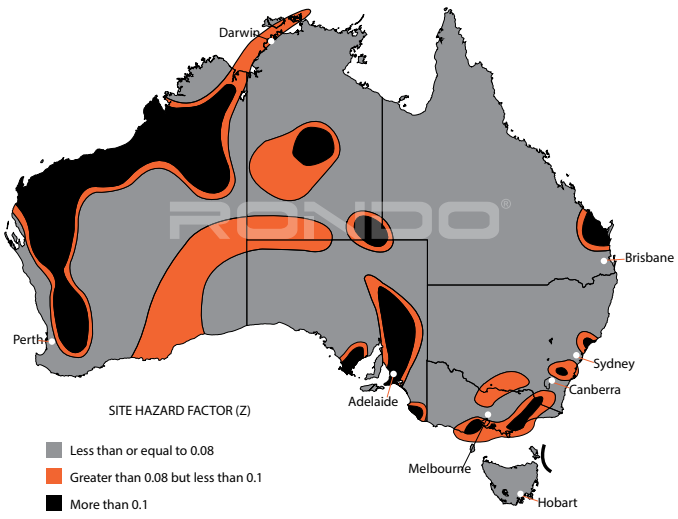
Impact of building location, importance level and site sub-soil class on fastener requirements

The recommendations in Table F.3.2 are conservative and take into account a wide range of building types and safety considerations. Direct reference to Table F.3.2 may lead to the nomination of C2-qualified fasteners in more applications than would be required by Table F.3.1.

From 1 May 2023, according to Table F.3.2 fastener requirements, all Level of Importance (LOI) 4 buildings, and some LOI 2 and 3 buildings, will require C2-compliant fasteners for safety-critical applications.

Figure 1 below provides a map indicating the site hazard factors across Australia. Cross reference Figure 1 with Table 3, which shows how building importance level and site sub-soil class influence C1 or C2 fastener requirements for different buildings.

Figure 1. Site hazard factor for seismic performance categories.



Source: Rondo

Table 3. Selection of fasteners based on Figure 1 map, building importance level and soil sub-class.

MAP SHADING	SOIL / HAZARD FACTOR	BIL 2					BIL 3					BIL 4
		Ee	Dd	Cc	Bb	Aa	Ee	De	Cc	Bb	Aa	ALL
Grey	0.08	C2	C1	C1	N/A	N/A	C2	C2	C1	C1	C1	C2
Orange	0.09	C2	C2	C1	N/A	N/A	C2	C2	C1	C1	C1	C2
Black	0.10	C2	C2	C1	N/A	N/A	C2	C2	C2	C1	C1	C2
	0.11 to ≤0.12	C2	C2	C1	C1	N/A	C2	C2	C2	C1	C1	C2
	0.13	C2	C2	C2	C1	C1	C2	C2	C2	C1	C1	C2
	0.14 to ≤0.16	C2	C2	C2	C1	C1	C2	C2	C2	C2	C1	C2
	0.20 to ≤0.22	C2	C2	C2	C2	C1	C2					C2
	0.60	C2					C2					C2

N/A = Design of fastener for seismic action is required but the fastener does not require prequalification. C1 fasteners will be suitable in these cases.

Source: Rondo

C1 vs. C2: How are they different?

Fasteners are tested while being subjected to simulated seismic tension and shear loading, crack effects, and simulated seismic crack cycling. Only fasteners that have undergone evaluation in both cracked and uncracked concrete and have a valid ETA are pre-qualified for seismic testing.

Pre-qualification of fasteners for seismic actions is evaluated under seismic performance categories C1 and C2. These categories are explained below:

- **Performance category C1.** This category tests fasteners under pulsating tension load and alternating shear load while accounting for the effect of concrete cracking. For C1, a maximum crack width of 0.5mm is considered in the test program.
- **Performance category C2.** This category considers fastener reference tests to failure in addition to tests under pulsating tension load and alternating shear load while accounting for the effect of concrete cracking. For C2, a maximum crack width of 0.8mm is considered and cycled from 0.1 to 0.8mm. C2 is a more stringent seismic test program when compared to C1 and is difficult for many post-installed fasteners to qualify against.

Pre-qualified C1 fasteners come in sizes as small as M6, with a minimum embedment depth of 40 mm and a hole depth of 45 mm. Rondo, a leading wall and ceiling systems manufacturer, offers screw fasteners that carry an ETA with C2 pre-qualification as small as M8 that is 55mm long with a minimum embedment of 50mm and a minimum hole depth 5mm greater than embedment. See Table 4 for a comparison of drill depth between C1 and C2 fasteners.

Table 4. Drill depth comparison.

	C1 (mm)	C2 (mm)
Diameter	6	8
Length	43	55
Minimum Embedment Depth	40	50
Minimum Depth of Drill Hole	45	60

Source: Rondo

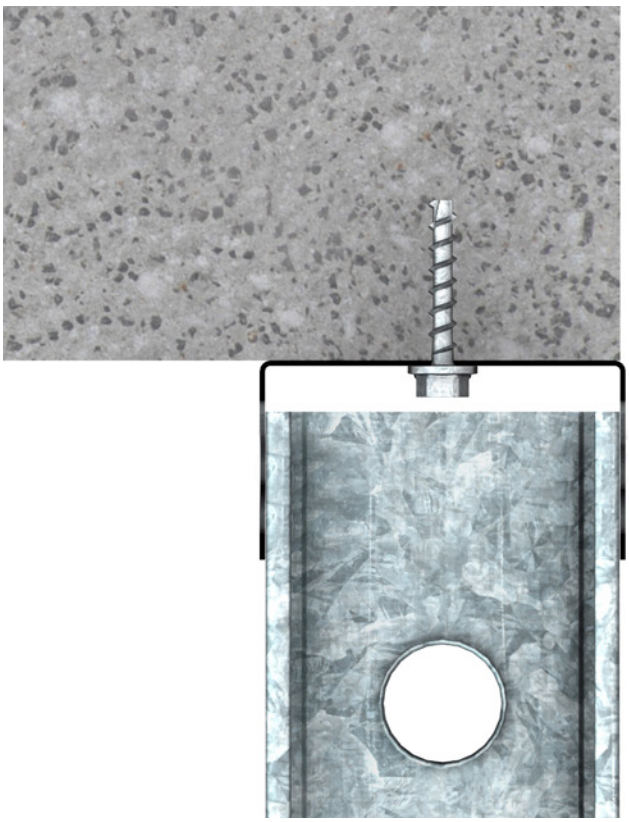
WHAT DOES AS 5216:2021 MEAN FOR PRACTITIONERS?

In the context of rising construction costs, supply chain disruptions and tightening construction schedules, the shift to C1 and C2 seismic performance categories creates additional challenges for the industry. Architects and designers will need to understand the changes and adjust drawings to include the changes. New requirements for C2 fasteners also have the potential to increase the cost of materials and labour, and negatively impact construction schedules.

The reason for this is simple: C2 fasteners are bigger and longer than their C1 counterparts, and thus require deeper and wider holes. The deeper the hole, the slower the drilling time. Larger bolts may be required. These extended drilling times and additional materials need to be considered early in the project so that they are factored into the construction schedule and budget.

To guarantee that fasteners are installed correctly, contractors might need to hire more experienced workers, which could also drive up costs.

The deeper holes and longer C2 fasteners required for compliance with AS 5216:2021 may clash with concrete slab reinforcement and compromise the strength of the slab. For reference, a typical slab for an apartment block can have steel reinforcement or tensioning as little as 50mm deep. To prove damage of slab tensioning from fastener installation has not occurred, slabs might need to be xrayed if reinforcment cover is limited. Additional time and budget will need to be allocated to x-ray the slab and produce the slab crack concrete reports, leading to increased project costs.



HOW RONDO CAN HELP

Rondo, a leading provider of innovative solutions for the construction industry, is committed to helping you achieve compliance in your building projects. Whether you are building a residential or commercial project, their new range of code compliant, ETA-approved fasteners complement their existing wall and ceiling systems and are suitable for Safety Critical, Cracked Concrete, Seismic and Fire Rated Applications.

Backed by Rondo's product guarantee and technical design support, fasteners such as the CERT-R-FIX® products are available to purchase as individual fastener components or as a completely assembled Rondo bracket via special order.

Rondo can also help you navigate the fastener requirement changes implemented by AS 5216:2021. Contact their technical support team for advice on how to prepare for the new requirements at https://www.rondo.com.au/support/product-support/technical-support.

"C2 is a more stringent seismic test program when compared to C1 and is difficult for many post-installed fasteners to qualify against."

References

1 Pokharel, Tilak, Jessey Lee, Anita Amirsardari and Emad Gad. “What is new in AS 5216:2021 and why it matters.” CIA Conference. http://www.ciaconference.com.au/concrete2021/pdf/full-paper_104.pdf (accessed 18 June 2023).

1 Ibid.

All information provided correct as of July 2023

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