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AS 5216:2021 Webinar Series

SEISMIC DESIGN OF FASTENERS IN ACCORDANCE WITH AS 5216:2021

Mon, 11 Oct 2021 | 12PM - 1PM

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Presenters

AEFAC
Australian Engineered Fasteners and Anchors Council

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Seismic Prequalification Requirements for Fasteners

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Seismic Design of Fasteners

Moderator: Dr. Jessey Lee

AEFAC Training and Development Manager

Senior Lecturer Swinburne University of Technology

3 Critical Elements to Achieve Quality Assurance

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01. Pre-qualification

Products independently tested and assessed to be "fit for purpose"

02. Design

Rigorous assessment to design for critical mode of failure

03. Installation

Informed and competent installer with appropriate supervision and experience

AEFAC - Introduction

AEFAC
Australian Engineered Fasteners and Anchors Council

AEFAC Founding Board Members

AEFAC Supporting Members

The role of AEFAC....

AEFAC
Australian Engineered Fasteners and Anchors Council

For Designers
Guidelines for the specification and design of fasteners

For Contractors
Training and certification

For Field Engineers
Guidelines for field testing

For Manufacturers
Minimum performance and standard specifications

For fastener Industry
Research and development

AEFAC Installer Certification Program

"The best anchor product is only as good as its installation"

www.aefac.com/icp - Free online training

Standard Development

SA TS 101 - 2015

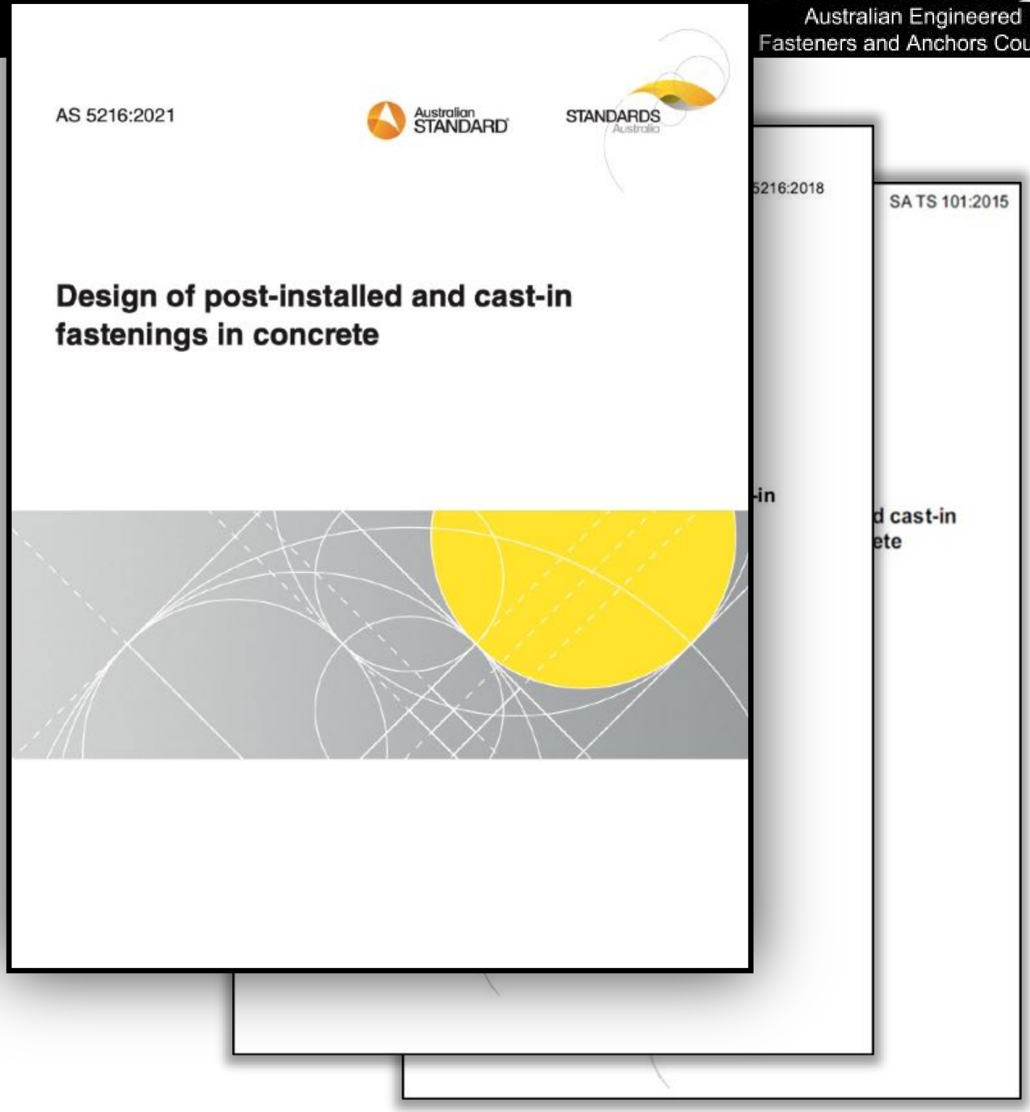
Design of post-installed and cast-in fastenings for use in concrete

AS 5216 - 2018

Design of post-installed and cast-in fastenings in concrete

AS 5216 - 2021

Design of post-installed and cast-in fastenings in concrete



Scope of AS 5216

- Post-installed fasteners
- Cast-in fasteners

- Design for seismic actions
- Anchor channel with 3-D loading
- Post-installed rebar connections
- Redundant non-structural connections
- Design for fire and durability
- Design for fatigue

Technical Publications

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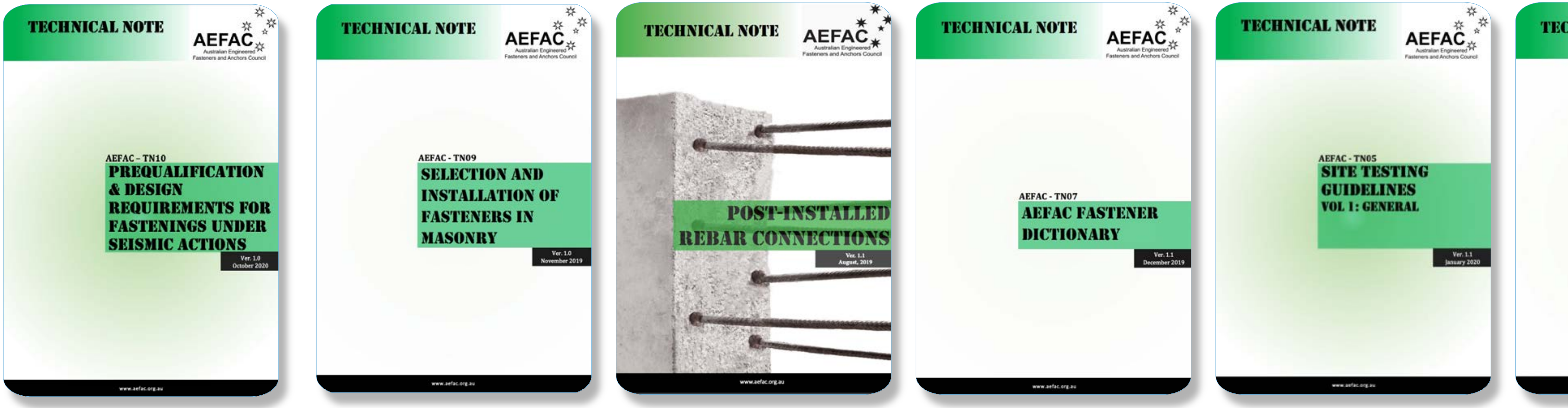

Vol 1: General
Vol 2: Proof Test
Vol 3: Ultimate Test
Vol 4: Masonry

All publications are available for free on
www.aefac.org.au

AEFAC Webinar Series on AS 5216:2021

WHAT'S NEW IN AS 5216:2021: Seismic Prequalification Requirements for Fasteners

AEFAC
Australian Engineered
Fasteners and Anchors Council

Dr. Anita Amirsardari
11 October 2021

Outline

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Fasteners and Anchors Council

1. Seismicity of Australia
2. Seismic provisions in AS 5216:2021
3. Fastener seismic prequalification requirements
4. Selection criteria for seismic performance categories – International practice
5. Rapid seismic assessment of buildings in Australia
6. Selection criteria for seismic performance categories – Australia
7. Comparison between Australian and international selection criteria
8. Conclusions

Seismicity of Australia

Australia is low-to-moderate seismic region

Geoscience Australia:

- Earthquakes > M5 may occur on average every 1 to 2 years
- Earthquakes > M6 may occur about every 10 years

Seismicity of Australia

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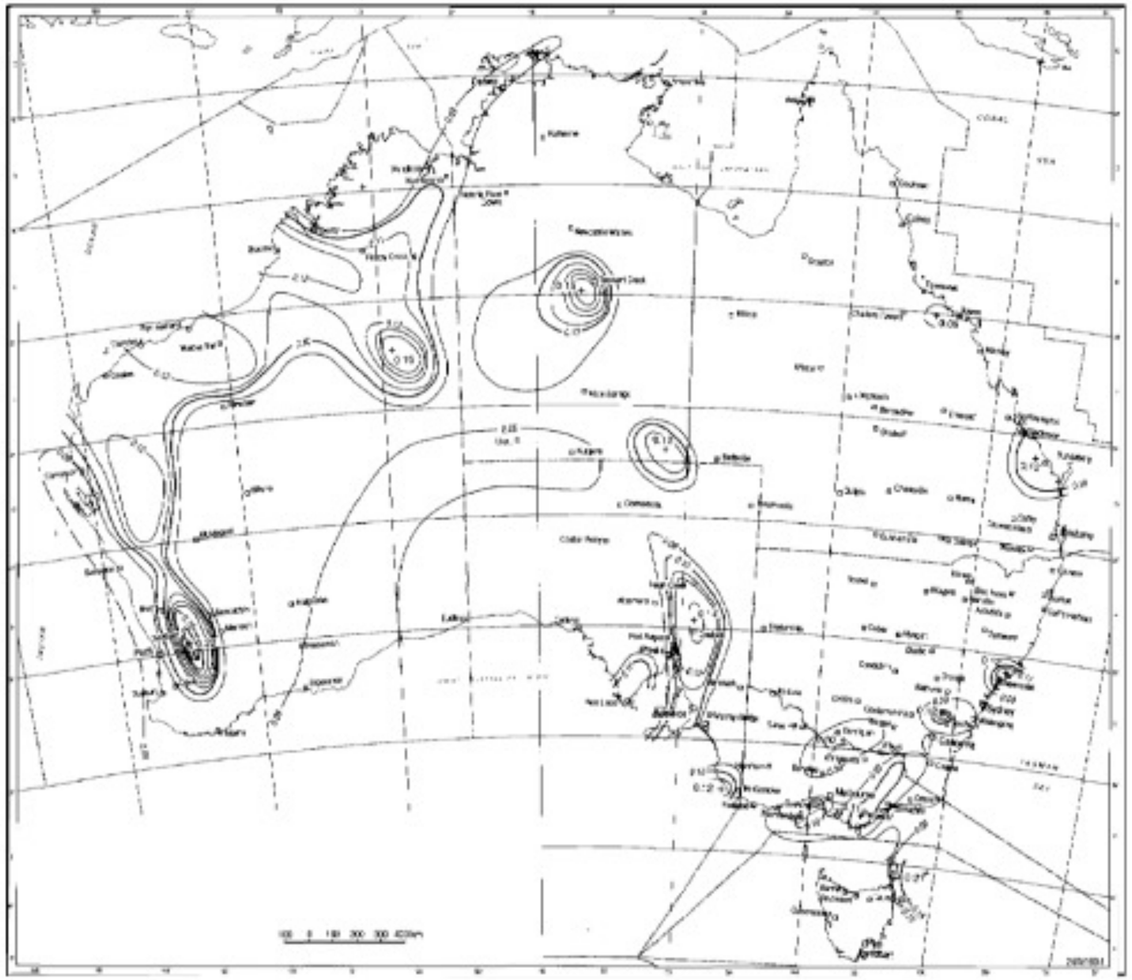

Earthquake hazard map showing earthquake design factor (Z) in AS 1170.4:2007 (Reconfirmed 2018)

Minimum k_pZ values in AS 1170.4 since 2018

TABLE 3.3

MINIMUM k_pZ VALUES FOR AUSTRALIA

Annual probability of exceedance	Minimum value of k_pZ
1/500	0.08
1/1000	0.10
1/1500	0.12
1/2000	0.14
1/2500	0.15

Z: hazard design factor
K_p: probability factor for annual probability of exceedance

Seismicity of Australia

1989 Newcastle earthquake, M5.6
13 fatalities, 160 injuries requiring hospitalisation
Damage to 50,000 buildings and 300 demolished
(Photo from Geoscience Australia)

1954 Adelaide earthquake, M5.5
Damage to 3000 buildings
(Photo from The Advertiser)

List of some previous earthquake:

- M6.3 Meeberrie (SA) earthquake in 1941
- M5.5 Adelaide (SA) earthquake in 1954
- M6.5 Meckering (WA) earthquake in 1968
- M6.1 Cadoux (WA) earthquake in 1979
- M6.6 Tennant Creek (TN) earthquake in 1988
- M5.6 Newcastle (NSW) earthquake in 1989
- M5.4 Ellalong earthquake (NSW) in 1994
- M5.2 Kalgoorlie-Boulder (WA) earthquake in 2010
- M5.2 Moe (VIC) earthquake in 2012
- M5.9 Woods Point (VIC) earthquake in 2021

Seismicity of Australia

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Damaged building on Chapel Street
(Photo from ABC News)

- 22 September 2021 M5.9 earthquake, northeast of Woods Point, Victoria (Geoscience Australia)
- Approximately less than 20% of design event for most buildings in Melbourne.
- Minor structural damage in metropolitan Melbourne, more than 130 km from epicentre of Earthquake.
- Damage caused to most vulnerable structures - unreinforced masonry buildings

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AS 5216:2021 Appendix F – Design of fastenings under seismic actions

- **Clause F.1 – General**
- **Clause F.2 – Scope**
  - Structural and non-structural elements that need to be designed for earthquake actions in accordance with AS 1170.4.
  - Post-installed fasteners located in region of concrete members where concrete spalling or yielding of reinforcement is not expected to take place.
  - Other details provided in Clause F.2
- **Clause F.3 – Prequalification requirements → seismic performance categories**
- **Clauses F.4 to F.7 – Design requirements → design actions and resistance**

Available from https://www.aefac.org.au/

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Seismic prequalification requirements

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Fasteners do not have predictable capacities for all failure mechanisms:

- Require prequalification to define their performance for their intended use.
- European Assessment Documents (EAD) or Technical Reports (TR)

1. Uncracked concrete

- Tests for reliability and service-conditions of the concrete substrate.

2. Cracked concrete

- Tested in crack widths ≈ 0.3 mm
- Tests for reliability and service-conditions of the concrete substrate.

3. Seismic performance category 1 (C1)

- Tested in max. crack width = 0.5 mm (static)
- Tests for seismic conditions

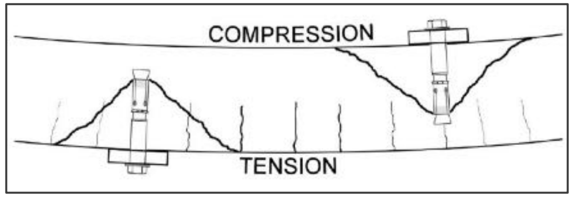
4. Seismic performance category 2 (C2)

- Tested in max. crack width = 0.8 mm (static & cyclic)
- Tests for seismic conditions

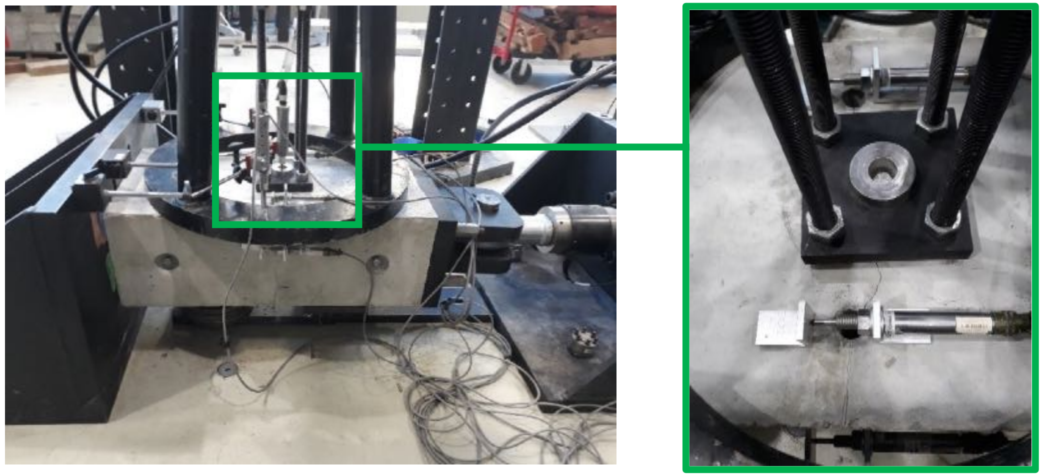
AS 5216:2018 (items 1–2)

AS 5216:2021 (items 1–4)

EAD example



Fasteners installed in cracked concrete



Testing of fastener in cracked concrete at Swinburne University

Seismic prequalification requirements

Fasteners do not have predictable capacities for all failure mechanisms:

- Require prequalification to define their performance for their intended use.
- European Assessment Documents (EAD) or Technical Reports (TR)

1. Uncracked concrete

- Tests for reliability and service-conditions of the concrete substrate.

2. Cracked concrete

- Tested in crack widths ≈ 0.3 mm
- Tests for reliability and service-conditions of the concrete substrate.

3. Seismic performance category 1 (C1)

- Tested in max. crack width = 0.5 mm (static)
- Tests for seismic conditions

4. Seismic performance category 2 (C2)

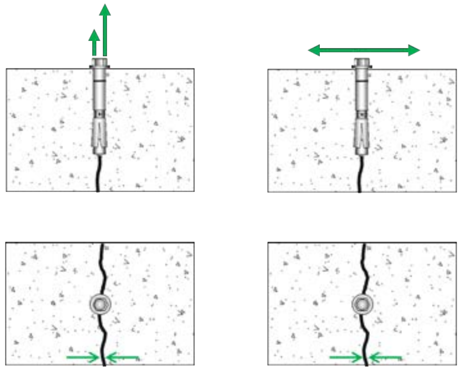
- Tested in max. crack width = 0.8 mm (static & cyclic)
- Tests for seismic conditions

Introduced in Europe in 2013, EOTA TR 049 (European Organisation for Technical Assessment)

C1

Table 2.1 Additional tests for qualification of anchors under category C1

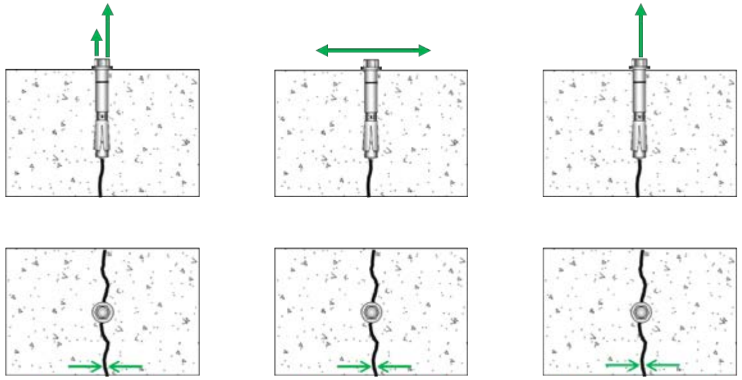
	Purpose of test	Concrete	Crack width Δw [1] [mm]	Minimum number of tests [2]	Test procedure see Section	Assessment criteria see Section
C1.1	Functioning under pulsating tension load	C20/25	0,5	5	2.3.2	3.1.1
C1.2	Functioning under alternating shear load	C20/25	0,5	5	2.3.3	3.1.2



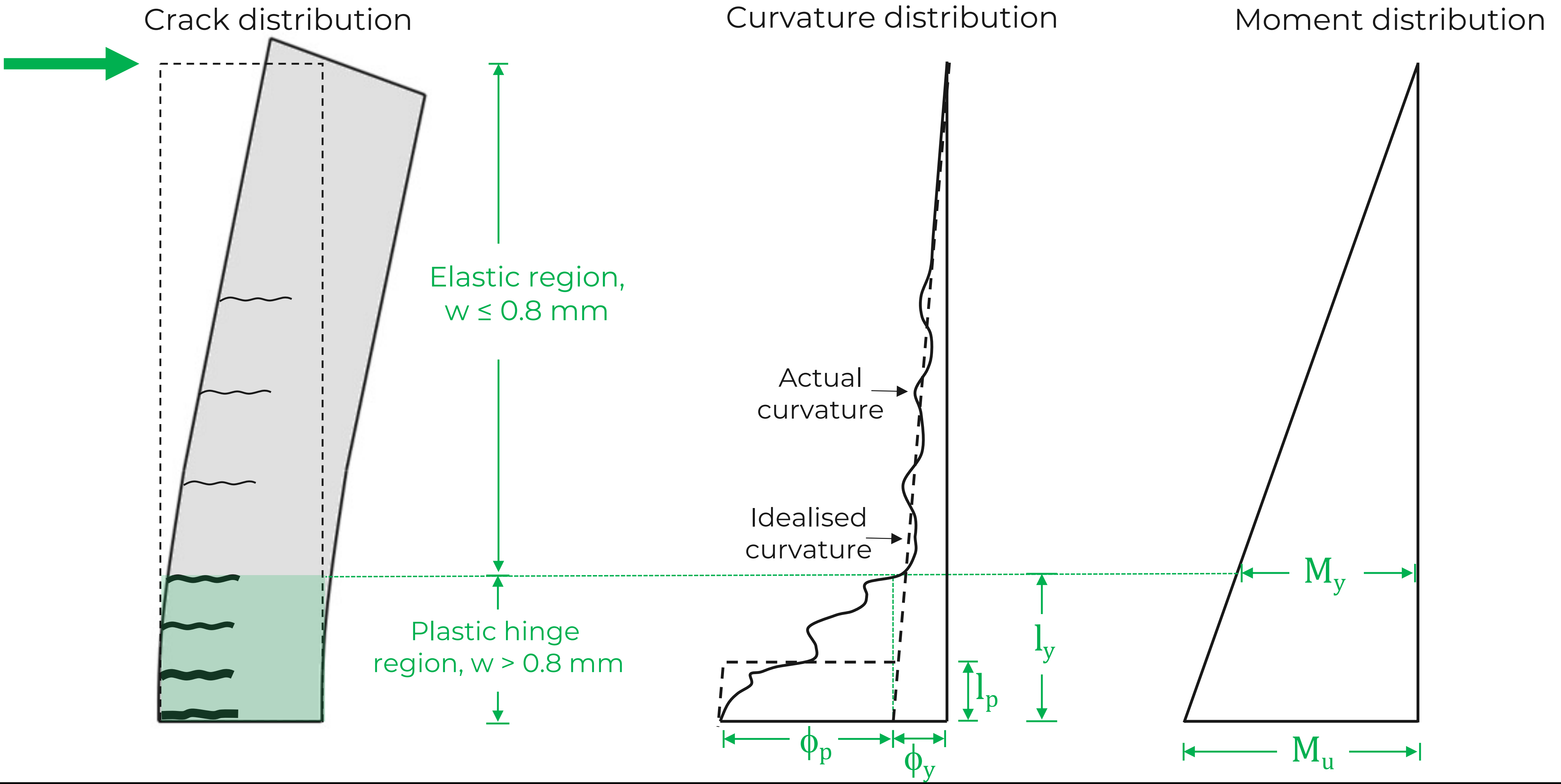
C2

Table 2.4 Additional tests for qualification of anchors under category C2

Test no.	Purpose of test	Concrete	Crack width Δw [1] [mm]	Minimum number of tests [2]	Test procedure see Section	Assessment criteria see Section
C2.1a	Reference tension tests in low strength concrete	C20/25	0,8	5	2.4.2	3.2.1, 3.2.2
C2.1b	Tension tests in high strength concrete	C50/60	0,8	5	2.4.2	3.2.1, 3.2.2
C2.2 [3]	Reference shear tests	C20/25	0,8	5	2.4.2	3.2.1, 3.2.3
C2.3	Functioning under pulsating tension load	C20/25	0,5 ($\le 0,5 \cdot N/N_{max}$) [4] 0,8 ($> 0,5 \cdot N/N_{max}$)	5	2.4.3	3.2.1, 3.2.4
C2.4	Functioning under alternating shear load	C20/25	0,8	5	2.4.4	3.2.1, 3.2.5
C2.5	Functioning with tension load under varying crack width	C20/25	$\Delta w_1 = 0,0$ [5] $\Delta w_2 = 0,8$	5	2.4.5	3.2.1, 3.2.6



Seismic prequalification requirements



What level of prequalification is required for fasteners designed to resist seismic actions?

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Selection criteria - Eurocode

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Recommended seismic performance categories in accordance with EN 1992-4

Seismicity level		Importance class			
Class	$a_g S$ (in g's)	I	II	III	IV
Very low	$a_g S \leq 0.05$	No seismic performance category required			
Low	$0.05 < a_g S \leq 0.1$	C1	C1[1] or C2[2]	C1[1] or C2[2]	C2
> Low	$a_g S > 0.1$	C1	C2	C2	C2

a_g= design ground acceleration | S= site amplification factor
[1]For connecting non-structural components to structures |[2]For connecting structural components to structures.

1. **Seismicity**
2. **Local site conditions**
3. **Importance level**
4. **Structural or non-structural connection**

Selection criteria - Germany

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Minimum seismic performance categories in accordance with DIN EN 1992-4/NA

Crack width under design earthquake	Behaviour factor used to estimate crack widths	Prequalification requirement
$w_k \leq 0.3\ mm$	$q = 1.0$	Cracked concrete
$w_k \leq 0.5\ mm$	$1.0 < q \leq 1.5$	C1
$w_k \leq 0.8\ mm$	$1.5 < q \leq 3.0$	C2
$w_k > 0.8\ mm$		Fastenings in plastic hinge areas not covered by DIN EN 1992-4

w_k = characteristic crack width (95 percentile) in accordance with EN 1992-1-1 and DIN EN 1992-1-1/NA.

1. **Crack widths, or**
2. **Behaviour factor is used to approximate expected crack widths (q is similar to $\frac{\mu}{S_p}$)**

Selection criteria – USA

Seismic prequalification is necessary for fasteners in structures which are assigned to Seismic Design Category (SDC) C, D, E, or F.

Assignment of SDC in accordance with ASCE/SEI 7

Short period (in g's)	1 second period (in g's)	Risk category	
		I, II, or III	IV
$S_{DS} < 0.167$	$S_{D1} < 0.067$	A	A
$0.167 \leq S_{DS} < 0.33$	$0.067 \leq S_{D1} < 0.133$	B	C
$0.33 \leq S_{DS} < 0.50$	$0.133 \leq S_{D1} < 0.20$	C	D
$S_{DS} \geq 0.50$	$S_{D1} \geq 0.20$	D	D
Not applicable	$S_1 \geq 0.75$	E	F

S_{DS} = design earthquake spectral acceleration at short periods; S_{D1} = design earthquake spectral acceleration at 1 second period; S_1 = the mapped risk-targeted maximum considered earthquake (MCE_R) spectral response parameter at 1 second period.

1. **Seismicity**
2. **Local site conditions**
3. **Risk category**

Potentially will incorporate structural response parameters with introduction of second seismic performance category

Selection criteria

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- Each criterion is highly dependent on the country's/region's seismicity, design and construction practice

- Considered:
    1. Seismic demand,
    2. Design of the structure, and/or
    3. Consequence of failure of the structure

- What is suitable for Australia?

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Rapid assessment

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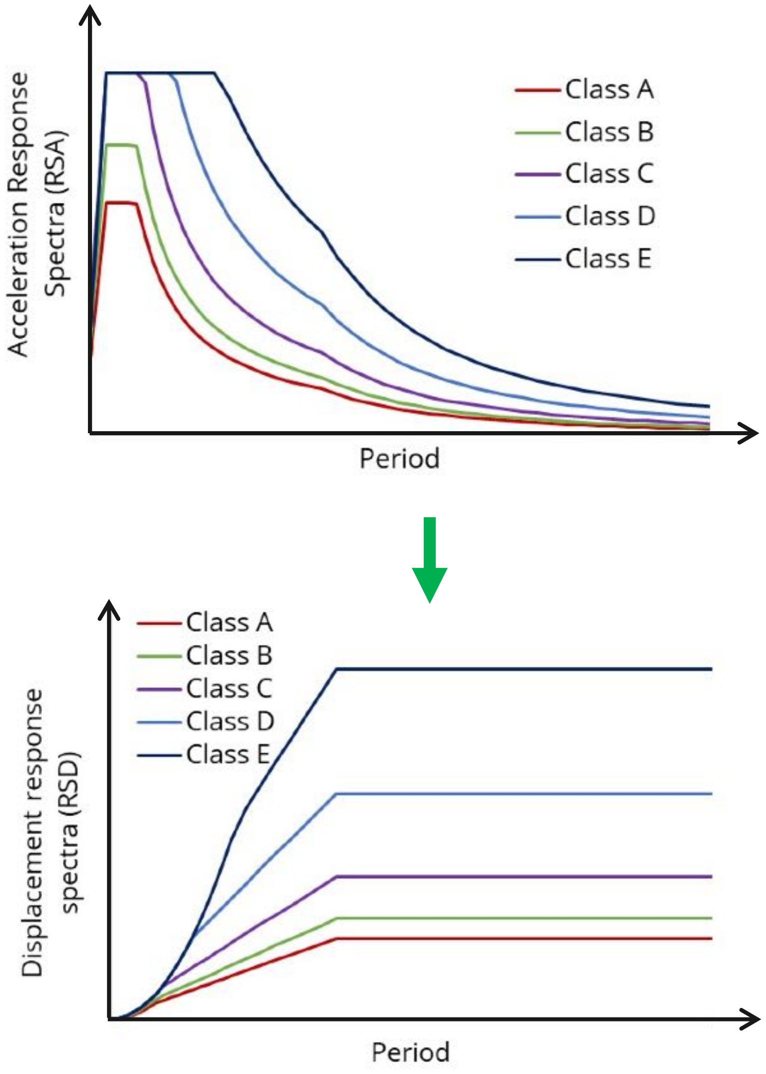
Displacement-based principles

Demand

- Estimating interstorey drift based on seismicity, fundamental period of the structure, and structural system.

Capacity

- Interstorey drift is related to expected level of damage of building components



Rapid assessment - demand

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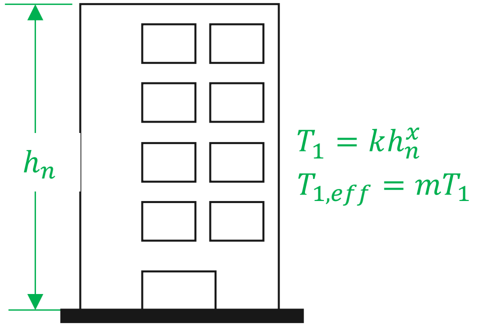
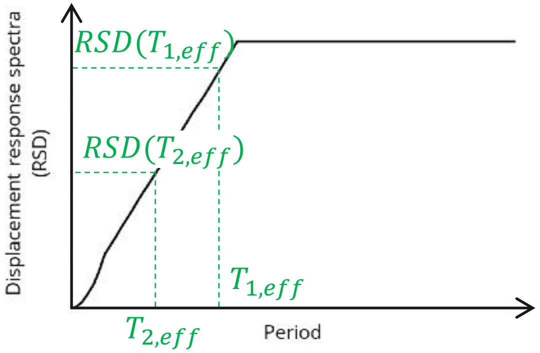
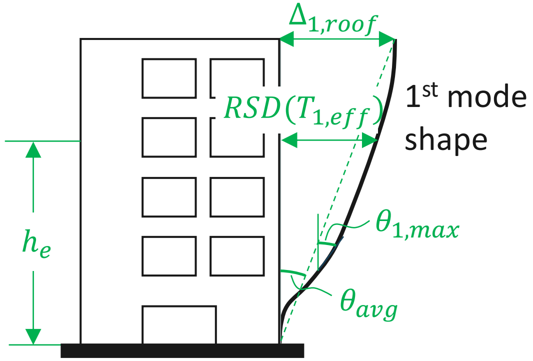
Rapid assessment approach provided in Tsang et al. (2009) and incorporating amplifications of drifts due to plan-asymmetry based on Lumantarna et al. (2019) recommendation.



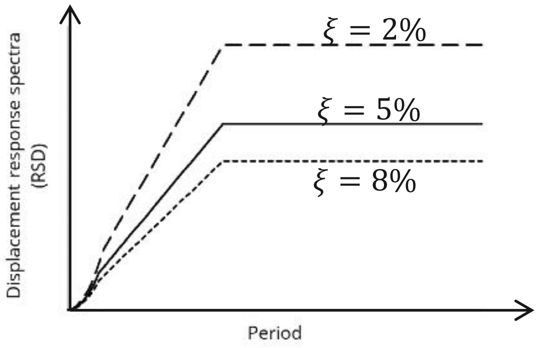
1. Effective building periods are calculated for fundamental periods



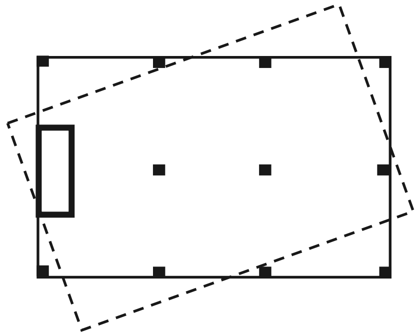
2. Spectral displacement response obtained at effective fundamental periods



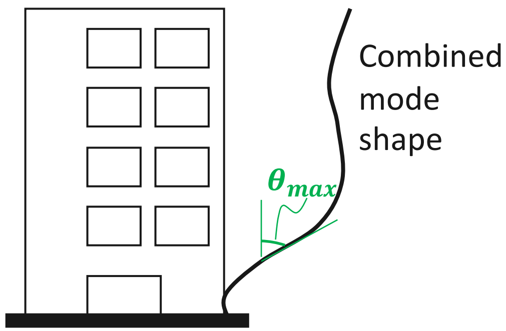
3. Maximum interstorey drift calculated for the first fundamental period



4. Incorporation of higher mode effects and damping modification to account for inelastic effects



5. Amplification of drifts due to plan-asymmetry



6. Final estimate of maximum interstorey drift

Rapid assessment – capacity

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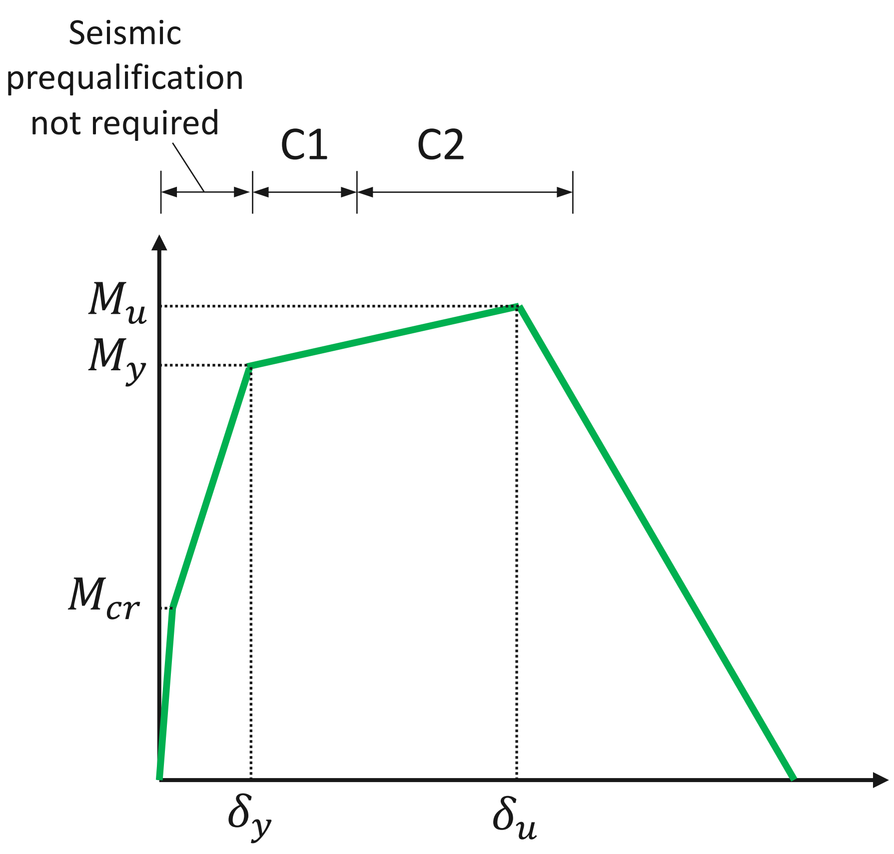
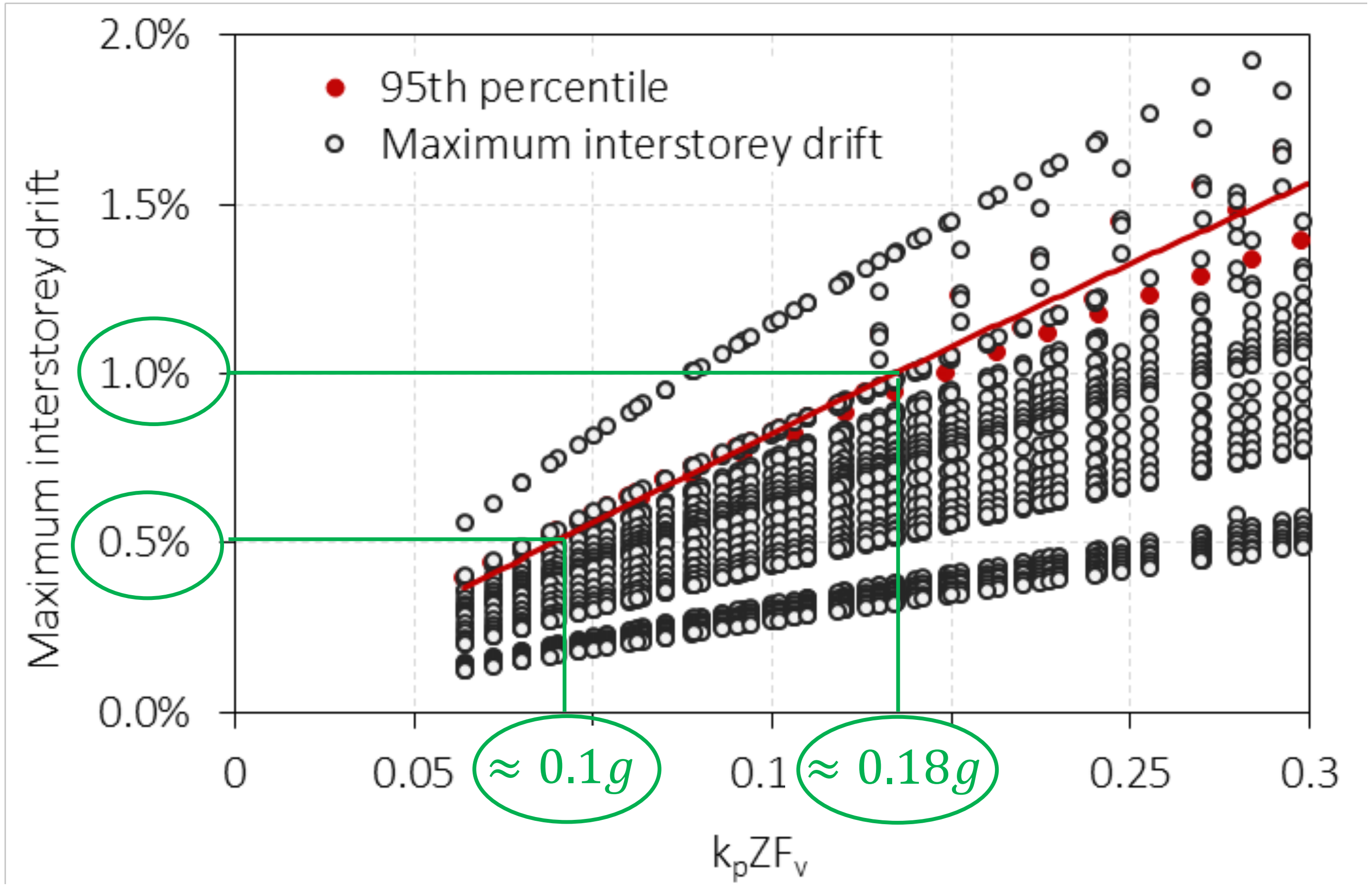
Interstorey drift limits

Interstorey drift (ISD) criteria	Building component damage state	Fastener prequalification requirement
$ISD \leq 0.5\%$	Building components are less than or close to initial yield in plastic hinge region.	Seismic prequalification not required
$0.5\% < ISD \leq 1.0\%$	Building components are starting to yield and forming plastic hinge regions.	C1
$ISD \geq 1.0\%$	Building components are developing full plastic hinges and may be close to reaching their ultimate drift capacity.	C2

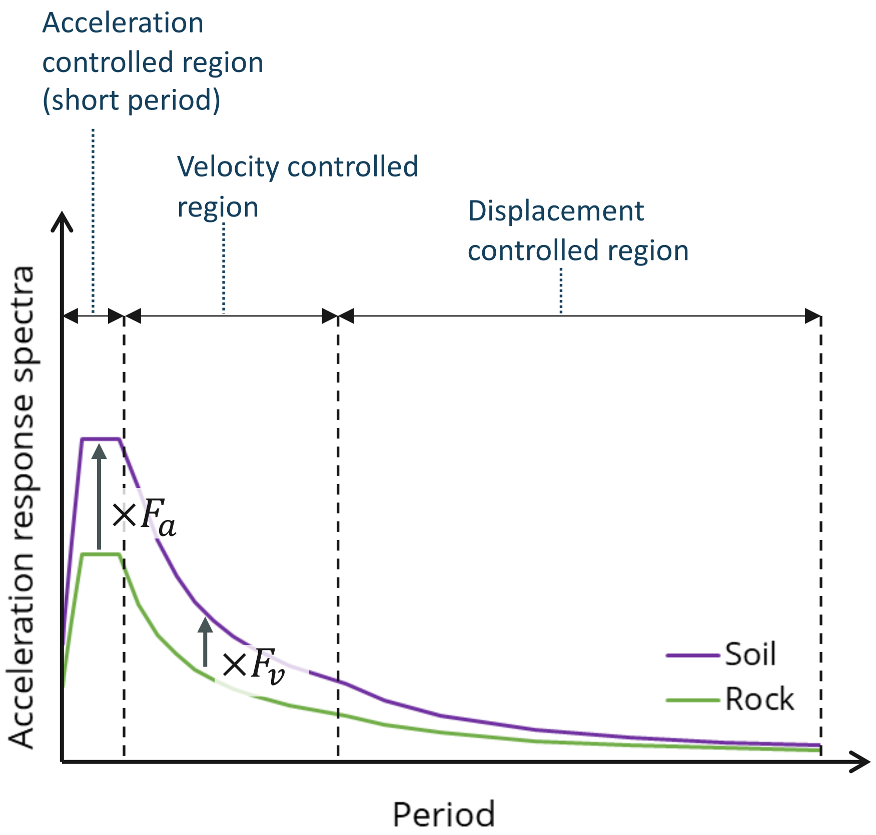
Building component moment-drift response



Rapid assessment



k_p: probability factor
Z: earthquake hazard design factor
F_v: site amplification factor in the velocity controlled region



Rapid assessment

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Minimum recommended seismic performance categories for fasteners

$k_p Z F_v$ (in g's)	Importance level			
	1	2	3	4
$k_p Z F_v \leq 0.1$	Seismic prequalification is not required	Seismic prequalification is not required	C1	C2
$0.1 < k_p Z F_v \leq 0.18$		C1	C1	C2
$k_p Z F_v > 0.18$		C2	C2	C2

1. **Seismicity**
2. **Local site conditions**
3. **Importance level**

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Informative requirement

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Minimum recommended seismic performance categories for fasteners

Importance level	$(k_p Z)$ for site sub-soil class					Seismic performance category
	E	D	C	B	A	
2	Not applicable	Not applicable	Not applicable	≤ 0.1	≤ 0.12	Seismic prequalification is not required
	Not applicable	0.08	≤ 0.12	> 0.1 to ≤ 0.18	> 0.12 to ≤ 0.22	C1
	≥ 0.08	> 0.08	> 0.12	> 0.18	> 0.22	C2
3	Not applicable	0.08	≤ 0.12	≤ 0.18	≤ 0.22	C1
	≥ 0.08	> 0.08	> 0.12	> 0.18	> 0.22	C2
4	≥ 0.08					C2

Normative requirement

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Consider expected crack widths and the effects of potential opening/closing of the cracks under seismic loading

Minimum required seismic performance categories for fasteners

Crack width under design earthquake[1]	Fastener seismic performance category
$w \leq 0.3$mm	Seismic prequalification is not required
$w \leq 0.5$mm	C1
$w \leq 0.8$mm	C2
$w > 0.8$mm (plastic hinge region)	Not covered[2]

[1] The expected crack widths may be calculated by using the equation for maximum crack width (w) in accordance with AS 3600:2018

[2] For crack widths greater than 0.8 mm special design and alternative solutions may be required.

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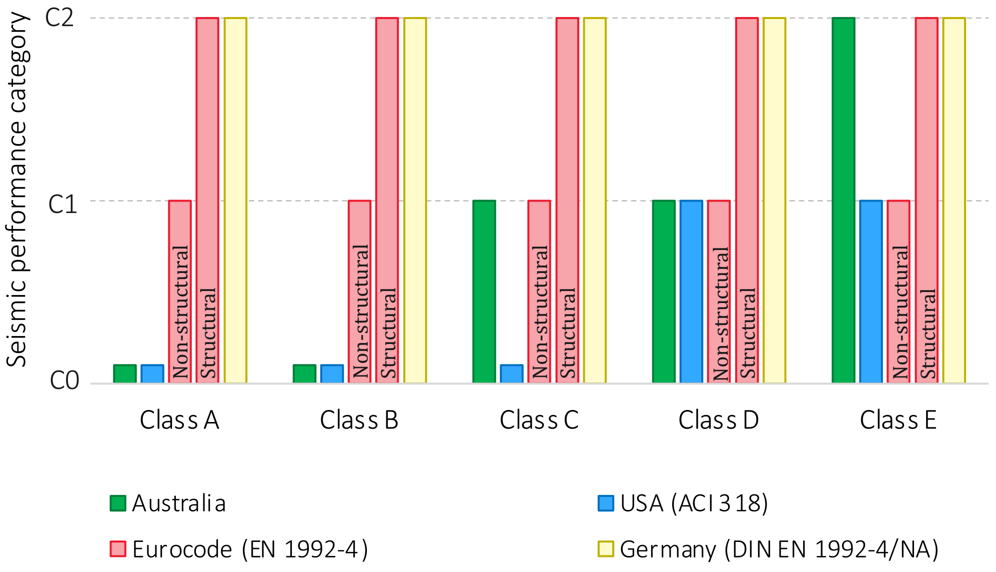
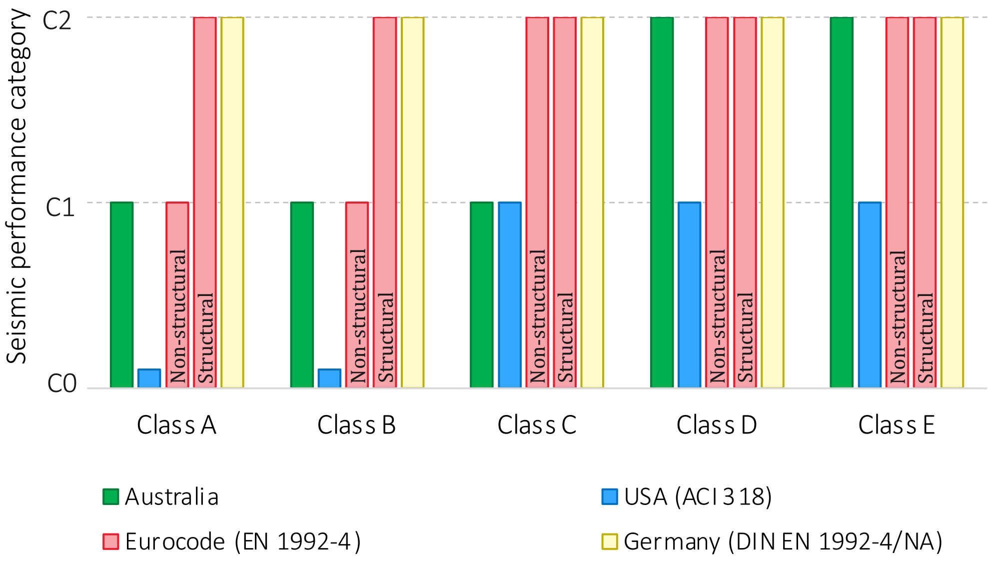
Comparison with international selection criteria

Importance level $= 2 \mid Z = 0.08 \mid \frac{\mu}{S_p} = 2.6$



Importance level $= 3 \mid Z = 0.08 \mid \frac{\mu}{S_p} = 2.6$



NOTE

C0: Seismic prequalification not required, i.e. only cracked concrete prequalification is required

Comparison with international selection criteria

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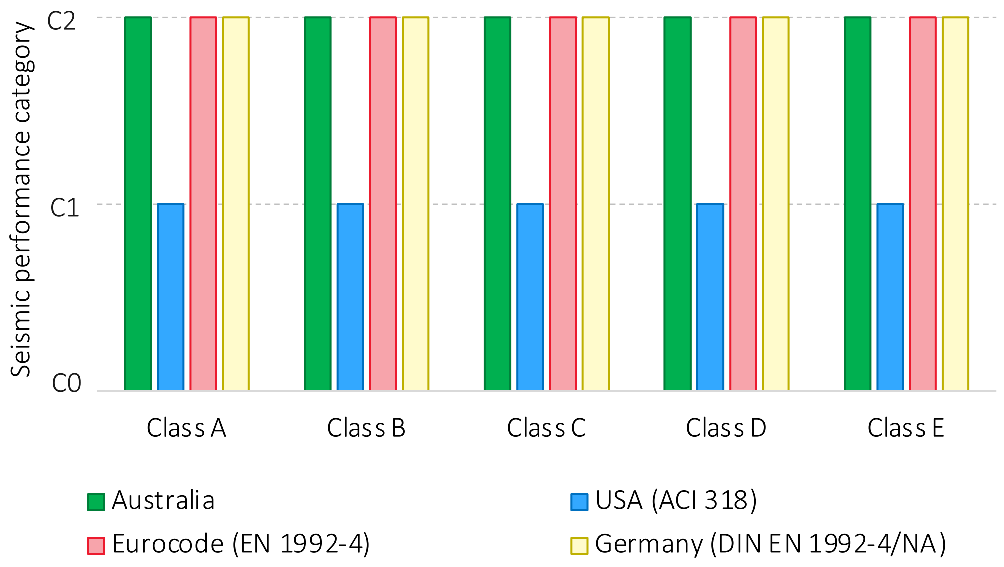
$\text{Importance level} = 4 \mid Z = 0.08 \mid \frac{\mu}{S_p} = 2.6$



NOTE
C0: Seismic prequalification not required, i.e. only cracked concrete prequalification is required

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Conclusions

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Seismic performance categories in AS 5216:2021

1. Normative requirement

Minimum required seismic performance categories for fasteners

Crack width under design earthquake[1]	Fastener seismic performance category
$w \leq 0.3mm$	Seismic prequalification is not required
$w \leq 0.5mm$	C1
$w \leq 0.8mm$	C2
$w > 0.8mm$ (plastic hinge region)	Not covered[2]

2. Informative requirement

Minimum recommended seismic performance categories for fasteners

Importance level	$(k_p Z)$ for site sub-soil class E	D	C	B	A	Seismic performance category
2	Not applicable	Not applicable	Not applicable	≤ 0.1	≤ 0.12	Seismic prequalification is not required
2	Not applicable	0.08	≤ 0.12	> 0.1 to ≤ 0.18	> 0.12 to ≤ 0.22	C1
2	≥ 0.08	> 0.08	> 0.12	> 0.18	> 0.22	C2
3	Not applicable	0.08	≤ 0.12	≤ 0.18	≤ 0.22	C1
3	≥ 0.08	> 0.08	> 0.12	> 0.18	> 0.22	C2
4			≥ 0.08			C2

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Thank You!

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AEFAC Webinar Series on AS 5216:2021

WHAT'S NEW IN AS 5216:2021: Seismic Design of Fasteners

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Scope – Seismic Design of Fasteners

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- Only covers post-installed fasteners
- Seismic design tension/shear to a single fastener or a group of fasteners <=20% of total design tensile/shear load for the same combination
    - Section 8 of TN – option 1a, 1b and 2 can be omitted
- Stand-off fasteners (or grout layer >=0.5d) is not covered
- Fastenings for redundant non-structural applications are not covered
- Loosening of the nut or screw should be prevented
- Does not cover the fastening to plastic hinge region

Design Principles

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- Design of connections – Appendix F
- Design value of seismic actions – AS 1170.4
- Design method depends on ductility requirement of fastener
  - NO – connection is designed for maximum possible stress
  - YES – yield strength and deformation capacity of fastener are considered

- Option 1a
- Option 1b

No Ductility Requirement

- Option 2

Ductility Requirement

Design Principles

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- Option 1a – Capacity Design
  - Fixture/member reaches to maximum stress
  - Failure happens in the component to be connected
- Option 1b – Elastic Design
  - Elastic behaviour of fasteners and members are assumed
- Option 2 – Ductility Design
  - Ductility of the fasteners is considered

Design Principles – Option 1

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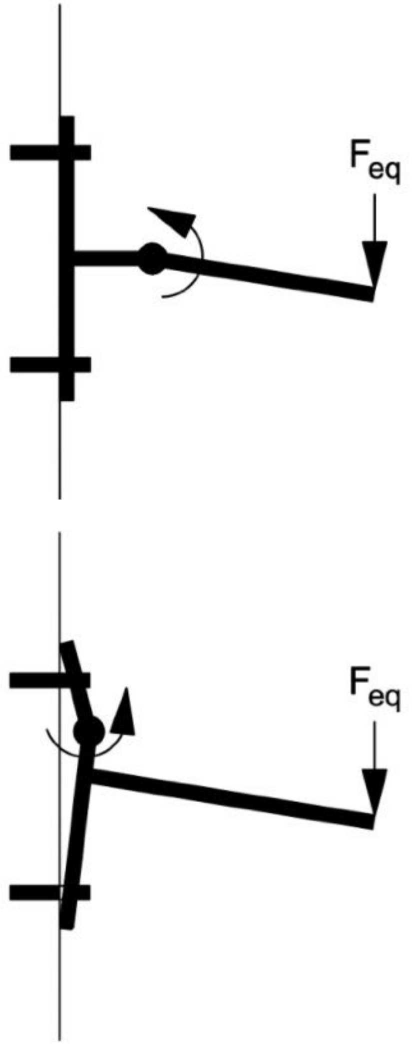
- Requirements
  - Fastener should meet non-seismic requirements
  - Cracked concrete should be assumed
  - Outside of the hinge region
- Option 1a – Capacity Design
  - Design for maximum tension and/or shear load
  - Ductile yield mechanism formed in fixture or member
  - Strain hardening and material over-strength must be considered
  - Load on the fasteners is limited



Design Principles – Option 1

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- Option 1b – Elastic Design
  - Maximum load obtained from design load combination that includes seismic action
  - Elastic behaviour of fasteners, fixtures and supporting structure
  - The design forces from AS 1170.4 assuming $^{S_p}/_{\mu} = 1.0$
  - Section 8 of AS 1170.4 for non-structural connections

Design Principles – Option 2

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- Option 2 – Ductility of fasteners
  - Maximum load obtained from design load combination that includes seismic action
  - C2 Seismic prequalification only
  - Tensile steel capacity < tension capacity from concrete related failure modes
  - Applies to pure tension
  - Other requirements
    - Elongation, Ultimate strength, Yield to Ultimate strength ratio, Breaking strain, Cross-sectional area etc.

Design Principles – Option 2

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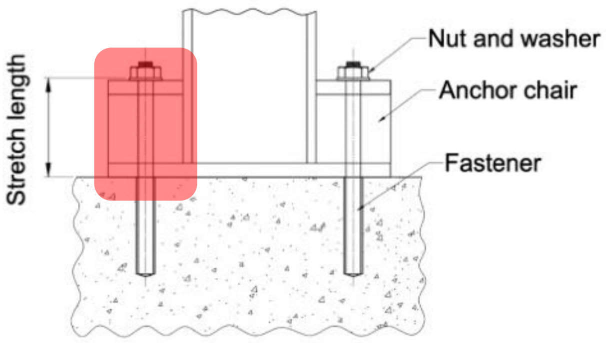
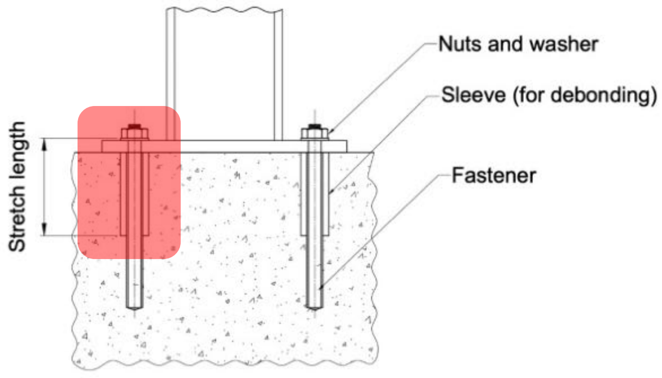
- To ensure steel failure
  - Condition A – one fastener in tension $R_{k,s,eq} \leq 0.7\ \phi_{inst} R_{k,conc,eq}$
  - Condition B – group of fasteners $\frac{R_{k,s,eq}}{S_h^*} \leq 0.7\ \phi_{inst} \frac{R_{k,conc,eq}}{S_g^*}$
  - + Condition – mechanical fasteners
- To transmit tensile load
  - Fastener should be ductile and shall have stretch length >=8d



(a) Anchor chair



(b) Sleeve or debonded length

Derivation of Forces

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- Design seismic forces, acting on the fixture determined according to AS 1170.4
- Design seismic forces for non-structural systems is determined according to Section 8 of AS 1170.4
- Maximum value of tension and shear act simultaneously (unless more accurate model available to prove otherwise)
- Distribution of forces to individual fasteners of a group is conducted according to Section 4 of AS 5216

Seismic Design Resistance

$$R_{d,eq} = \phi_i \, R_{k,eq}$$

Where,

ϕ_i = capacity reduction factor for strength of fastener or fastener group for failure mode *i* in accordance with AS 5216 (Cl 3.2.1)

$R_{k,eq}$ = characteristic seismic resistance of a fastener.

Characteristic Seismic Resistance

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$$R_{k,eq} = \alpha_{gap}\, \alpha_{eq}\, R^0_{k,eq}$$

Where,

α_{gap}	=	reduction factor to take into account for inertia effects due to an annular gap between fastener and fixture in case of shear loading and determined in accordance with Appendix A, AS 5216.
α_{eq}	=	factor to take into account the influence of seismic actions and associated cracking and determined in accordance with Table 6.
$R^0_{k,eq}$	=	basic characteristic seismic resistance for a given failure mode

Annular Gap (α_{gap})

- Forces are amplified due to annular gap under shear load
  - Hammer effect on fastener
- For the simplicity
  - This is considered in design rather than analysis
- If no information is available
  - $\alpha_{gap} = 1.0$ for no hole clearance
  - $\alpha_{gap} = 0.5$ for hole clearance

Seismic Action and Cracking (α_{eq})

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- Influence of seismic actions and associated cracking

Design Action	Failure mode	Single fastener[1]	Fastener group
Tension	Steel failure	1.0	1.0
	Concrete failure		
	- Undercut fasteners	1.0	0.85
	- All other fasteners	0.85	0.75
	Pull-out failure	1.0	0.85
	Combined pull-out and concrete failure (chemical fastener)	1.0	0.85
	Concrete splitting failure	1.0	0.85
	Concrete blow-out failure	1.0	0.85
	Steel failure of reinforcement	1.0	1.0
	Anchorage failure of reinforcement	0.85	0.75
Shear	Steel failure	1.0	0.85
	Concrete pry-out failure		
	- Undercut fasteners	1.0	0.85
	- All other fasteners	0.85	0.75
	Concrete edge failure	1.0	0.85
	Steel failure of reinforcement	1.0	1.0
	Anchorage failure of reinforcement	0.85	0.75

[1] This also applies where only one fastener in a group is subjected to tension load

Basic Ch. Seismic Resistance ($R^0_{k,eq}$)

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- For steel and pull-out failure under tension load and steel failure under shear load
  - Determined from Appendix A
  - $= N_{Rk,s,eq}, N_{Rk,p,eq}$ *and* $V_{Rk,s,eq}$
- For combined pull-out and concrete failure in case of post-installed bonded fasteners
  - Determined from Cl 6.2.5 replacing τ_{Rk} with $\tau_{Rk,eq}$
  - $N_{Rk,p} = N^0_{Rk,p}\left(\frac{A_{p,N}}{A^0_{p,N}}\right)\psi_{s,Np}\psi_{g,Np}\psi_{Re,N}\psi_{ec,Np}$
    - With $N_{Rk,p} = \tau_{Rk,eq}\pi d h_{ef}\psi_{sus}$
- For all other failure modes -- Ch 6 and 7 of AS 5216

Combined Tension and Shear

$$\left(\frac{N^*}{\phi_i\, N_{Rk,i,eq}}\right)^{k_{15}} + \left(\frac{V^*}{\phi_i\, V_{Rk,i,eq}}\right)^{k_{15}} \leq 1$$

- Steel failure mode

$N_{Rk,i,eq}$ $V_{Rk,i,eq}$ = for steel failure $N_{Rk,s,eq}$ and $V_{Rk,s,eq}$ for $N_{Rk,i,eq}$ and $V_{Rk,i,eq}$ shall be used, respectively;

- Other than steel failure mode

$N_{Rk,i,eq}$ $V_{Rk,i,eq}$ = for failure modes other than steel failure, largest ratio of $\frac{N^*}{\phi_i\, N_{Rk,i,eq}}$ and $\frac{V^*}{\phi_i\, V_{Rk,i,eq}}$ shall be used.

Displacement Requirements

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- The displacement at the damage limit state under tension and shear loads shall be limited to

$$\delta_{N,req(DLS)} \text{ and } \delta_{V,req(DLS)}$$

- The limiting displacement values shall be selected depending upon the requirements of the specific application.
- Design engineer must determine the allowable displacement in the analysis that is compatible with the requirements of the structure

Displacement Requirements

- Displacement of fasteners for tension and shear should be given in prequalification report (such as ETA)
- If the specified deformation values are greater than values required for an application
  - design value of the resistance should be reduced

$$N_{Rk,eq,red} = N_{Rk,eq} \frac{\delta_{N,req(DLS)}}{\delta_{N,eq(DLS)}}$$

$$V_{Rk,eq,red} = V_{Rk,eq} \frac{\delta_{V,req(DLS)}}{\delta_{V,eq(DLS)}}$$

Conclusions

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- AS 5216 has been revised which includes
  - Seismic design of post-installed fasteners
  - Post-installlled reinforcing bar connections
  - Anchor channel with longitudinal shear force
  - Fasteners for redundant non-structural systems
- Seismic performance categories C1 and C2 introduced
- Seismic design options 1a, 1b and 2 are introduced
- Design requirement
  - Strength requirements
  - Displacement requirements

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Thank You!

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