Steel Reinforcement Institute of Australia

AS 3600 Structural Integrity REO Fitment Options & A High Strength Reinforcing Steel Overview

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SRIA Steel Reinforcement Institute of Australia

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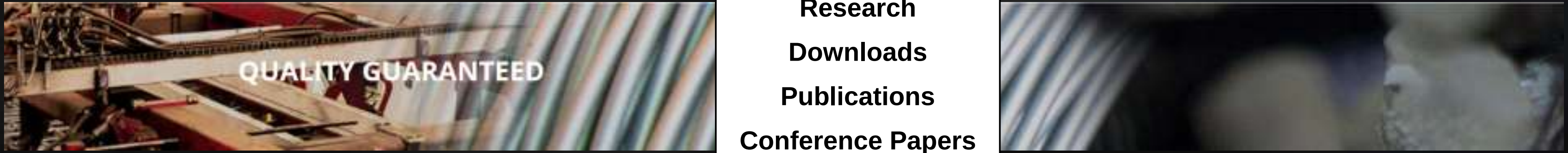
Benefits of Steel Reinforcement
Standards
Research
Downloads
Publications
Conference Papers



Welcome to SRIA

Steel Reinforcement Institute of Australia

The Steel Reinforcement Institute of Australia is Australia's leading non-profit institute for reinforcing steel, providing the hub for knowledge, industry linkage and support.

- Supports Australian capability & quality
- Offers practical solutions to the Australian building industry
- Educates industry
- Disseminates steel reinforcement knowledge via regular publications, lectures, seminars, research programs and tours
- Primarily funded by the vast majority of the processors of steel reinforcement used in Australian construction
- Supported by the founding Australian mill (supplier) members & associate members

THE BENEFITS OF REINFORCED CONCRETE

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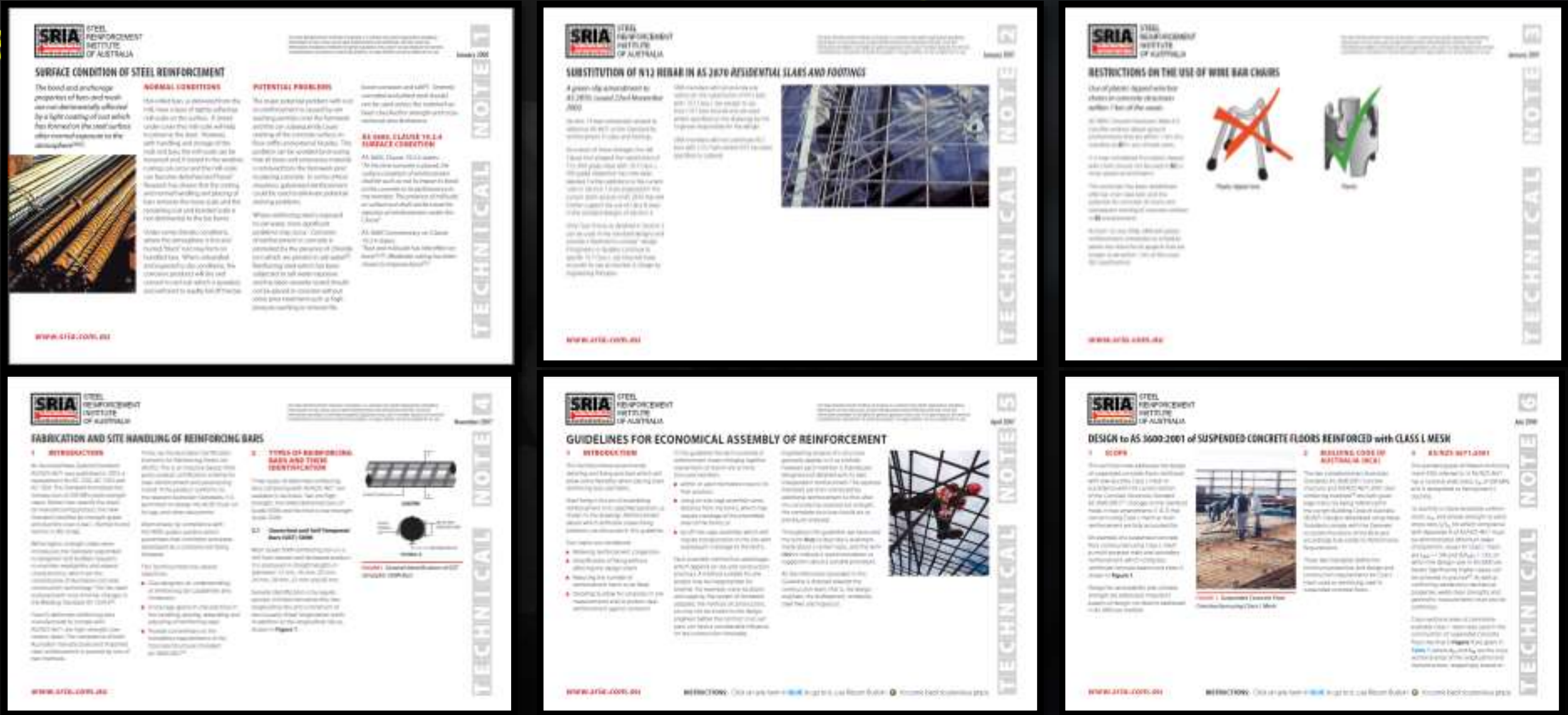
Technical Notes/Publications (sria.com.au



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Reinforcing Bar Classification

Two types – Ductility Class N and L

AS/NZS 4671 Designation	Steel Type	Yield Stress, R_e MPa	Ductility Class	Description	Typical Size mm
D500N	N	500	N	Hot-rolled Deformed bar	Coil 10, 12, 16 Straight 12 – 40 Special 50
R250N	R	250	N	Hot-rolled Plain round	6.5, 10, 12, 16, 20, 24
D250N	S	250	N	Hot-rolled Deformed bar	12 (pool steel)
D500L	L	500	L	Cold-rolled Deformed bar	5 - 12
R500L	L	500	L	Cold-drawn Round rod	5 - 12

NOTE: All steel reinforcement in Australia must comply with AS/NZS 4671 Steel reinforcing materials

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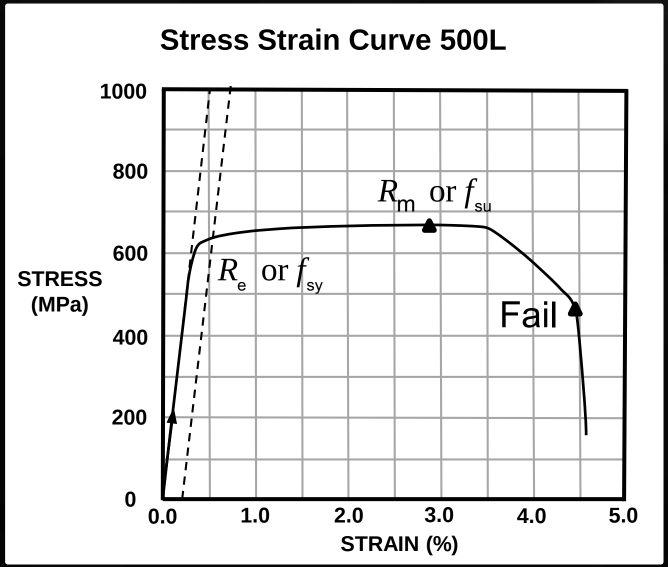
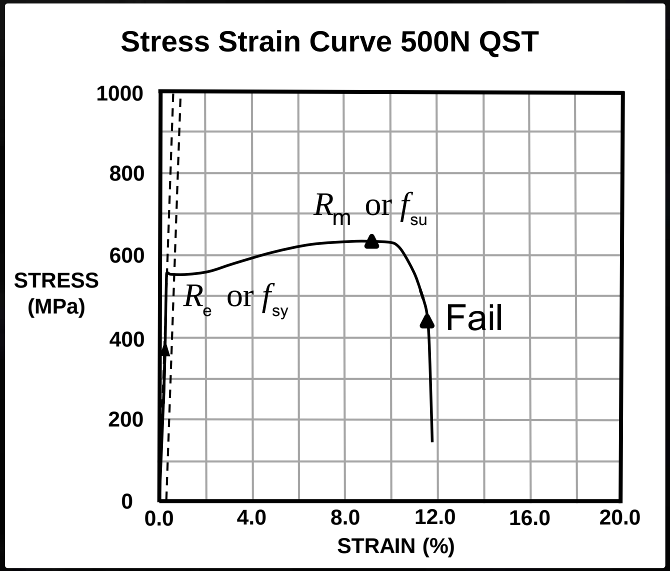
Mechanical Properties

AS/NZS 4671:2019 Steel for the reinforcement of concrete: Table 7.2(A&B)

Property		250N	500L	500N	600N	750N	Probability of exceedance
Nominal Diameter (mm)		12 (pool steel)	5 to 12	10 to 40	10 to 40	10 to 40	-
Yield Stress (MPa)	$R_{ek.L}$ $R_{ek.U}$	≥ 250 -	≥ 500 ≤ 750	≥ 500 ≤ 650	≥ 600 ≤ 750	≥ 750 ≤ 900	C_{vL}: P = 0.95 C_{vU}: P = 0.05
Ratio	$(R_m/R_e)_{k.L}$	≥ 1.08	≥ 1.03	≥ 1.08	≥ 1.08	≥ 1.04	C_{vL}: P = 0.90
Uniform Elongation (%)	$A_{gt.k.L}$	≥ 5.0	≥ 1.5	≥ 5.0	≥ 5.0	≥ 4.0	C_{vL}: P = 0.90





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Chemical Composition (from AS/NZS 4671)

Type of analysis	Chemical Composition (%) Max						
	C		P	S	Carbon Equivalence Value for Class		
	500L 500N	600N 750N	All steel grades		500L	500N	600N & 750N
Cast analysis	0.22	0.33	0.050	0.050	0.39	0.44	0.49
Product analysis	0.24	0.35	0.055	0.055	0.41	0.46	0.51

- Each welded D500L joint develops 50% of the bar's yield stress

Carbon Equivalence:

$$C_{eq} = C + \frac{Mn}{6} + \frac{Cr + Mo + V}{5} + \frac{Ni + Cu}{15}$$

Correct chemistry allows welding to AS/NZS 1554.3

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SRIA Quality Campaign

Don’t break the REO quality chain

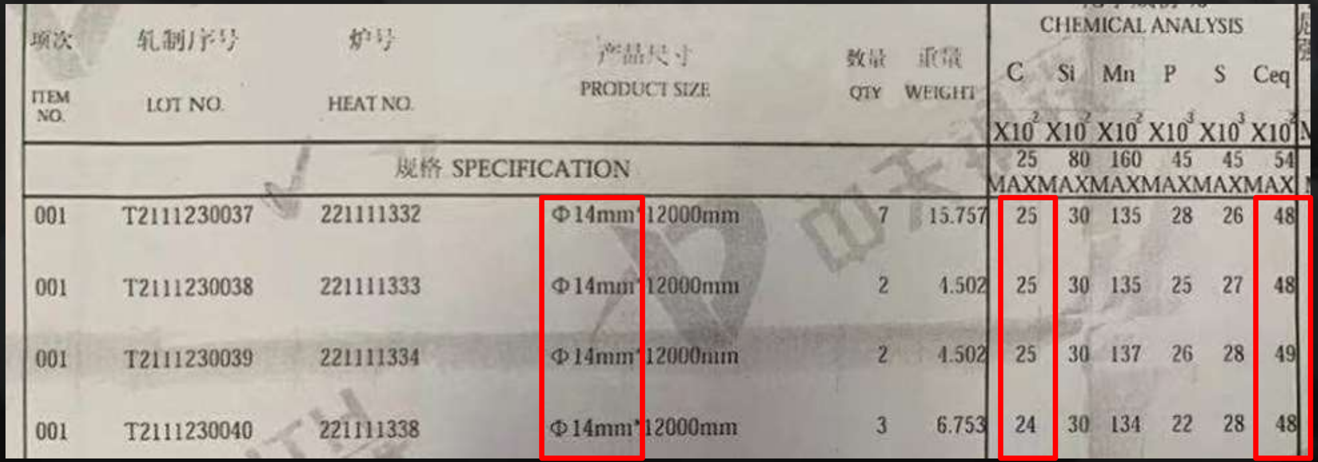
Look for the SRIA Logo

A JAS-ANZ accredited 3rd Party Processor Certificate should be obtained when purchasing reinforcement from a non-SRIA member.

Specify the Quality requirements

Chemical Composition

Example – Technical enquiry re HBR400 Chinese Steel for a major Project



项次 ITEM NO.	轧制序号 LOT NO.	炉号 HEAT NO.	产品尺寸 PRODUCT SIZE	数量 QTY	重量 WEIGHT	C $\times10^2$	Si $\times10^2$	Mn $\times10^2$	P $\times10^3$	S $\times10^3$	Ceq $\times10^2$
规格 SPECIFICATION						25 MAX	80 MAX	160 MAX	45 MAX	45 MAX	54 MAX
001	T2111230037	221111332	Φ14mm*12000mm	7	15.757	25	30	135	28	26	48
001	T2111230038	221111333	Φ14mm*12000mm	2	4.502	25	30	135	25	27	48
001	T2111230039	221111334	Φ14mm*12000mm	2	4.502	25	30	137	26	28	49
001	T2111230040	221111338	Φ14mm*12000mm	3	6.753	24	30	134	22	28	48

Bending Reinforcement Clause 17.2.3.2 of AS 3600 – Min. pin diameters

Assessment

- Carbon results exceed the 0.22% limit for all grades
- Carbon equivalence exceeds limit of 0.44% for Grade 500N
- Inferior weldability as a result
- Lower yield stress at 400 MPa
- Other deficiencies
- Manufacturer's ACRS Certification terminated for non-compliance

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Ensuring Quality Reinforcement

Third Party/Independent Certification - ACRS or Equivalent

Every project should specify one and obtain to guarantee quality

ACRS Mill Certificate Example

- Required by processors as proof that quality reinforcement used

2022
VALID TO 31 DEC

ACRS
PRODUCT CERTIFICATION

Australasian Certification Authority
for Reinforcing and Structural Steels Ltd

CERTIFICATE OF PRODUCT PERFORMANCE

Certificate Number: 31102

InfraBuild

INFRABUILD STEEL
LAVERTON, VIC, AUSTRALIA

SCOPE OF CERTIFICATION

Reinforcing Bar Manufactured in straight lengths to AS/NZS 4671:2019

Andrew Wheeler, Acting Executive Director

31 December 2022

November 2003

JAS-ANZ

ACRS Processor Certificate Example

- Required by purchasers to prove quality reinforcement delivered to site
- SRIA members must meet these requirements

2022
VALID TO 31 DEC

ACRS
PRODUCT CERTIFICATION

Australasian Certification Authority
for Reinforcing and Structural Steels Ltd

CERTIFICATE OF PRODUCT PERFORMANCE

Certificate Number: 811027

AUSREO

AUSREO
WETHERILL PARK, NSW, AUSTRALIA

Scope of Certification

Processing and distribution of carbon steel bars, welded mesh, including couplers

Andrew Wheeler, Acting Executive Director

31 December 2022

November 2008

JAS-ANZ

Processed steel reinforcing materials may only be relied upon as having the benefit of ACRS Product Scheme certification when manufactured by ACRS certified mills.

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Earthquake Frequency in Australia

- Earthquakes are a regular occurrence.
- Occur less frequently in Australia than New Zealand.
- Often occur in isolated areas but all Australian capital cities are expected to get a Newcastle type earthquake at some point (except Darwin & Hobart).
- On average Australia <u>will</u> experience:
  - 1 shallow earthquake of magnitude 6.0 or more once every 10 years (equivalent to the 2011 Christchurch earthquake – magnitude 6.2)
  - 2 magnitude 5 every year (equivalent to those in Newcastle and Adelaide)

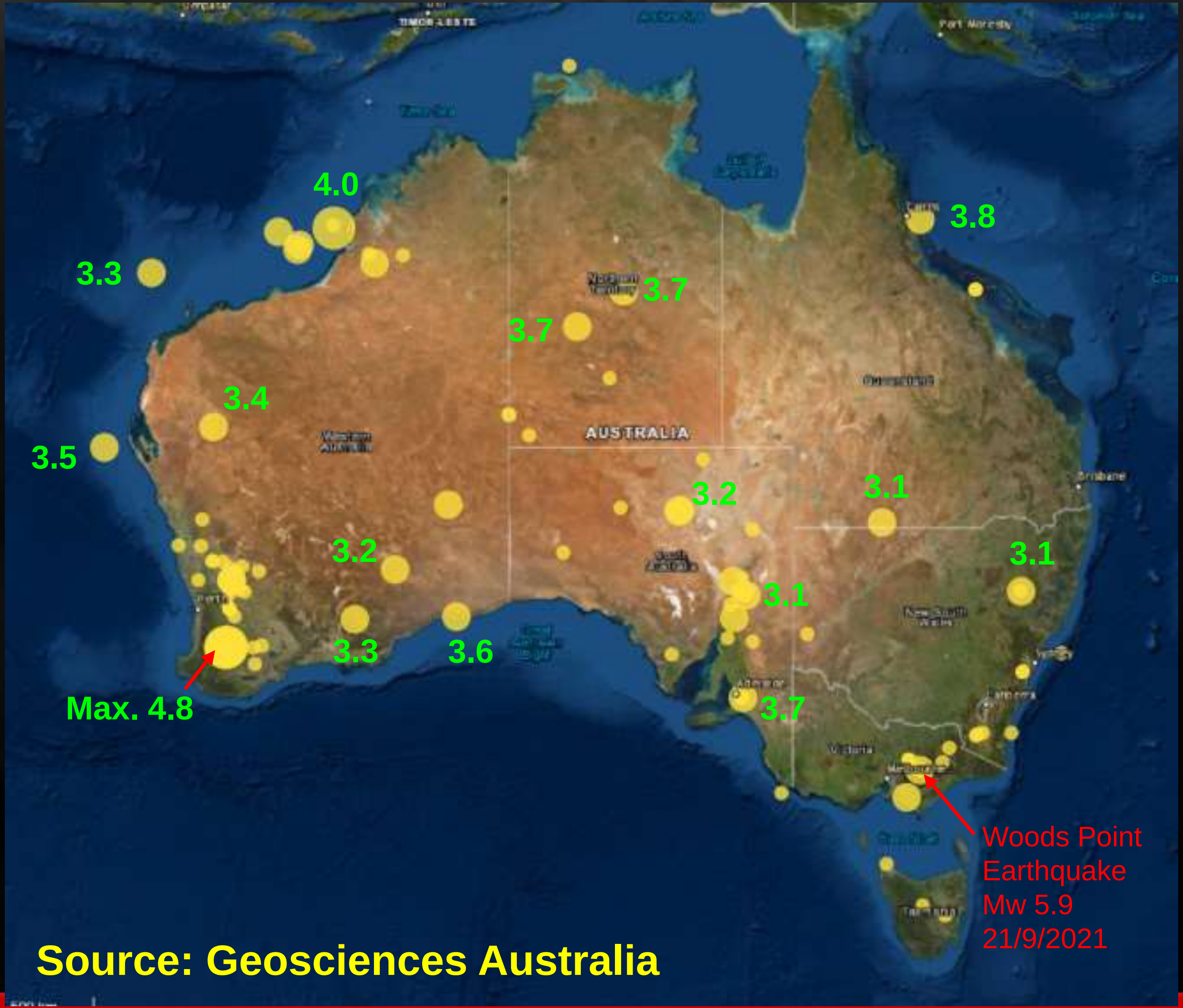
Watch ABC 7:30 Video:
https://www.abc.net.au/7.30/this-is-the-fatal-flaw-in-australias-earthquake/6806510

HAZARD NOTE
Bushfire & Natural Hazards CRC
Issue 112
February 2022


SUMMARY
Although the international reinsurance industry recognises that a moderate earthquake in Sydney is in their top-10 financial risks, there is a perception in the Australian construction industry that design for
poor use of money due
of a strong earthquake i
September 2021 earthqu
showed, cities like Melbo
to earthquake damage.
developed risk and econ
for earthquakes, which a
to conduct cost-benefit
economically justifiable
requirements for existin

Australia Experiences Earthquakes

1 January to 18 April 2022 ➡ Magnitude: 1.9 to 4.8 (283 events)



Source: Geosciences Australia

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Selecting Structural Ductility Factor

Ratio of Rare Event (2500 year) to Design Event (500 year)

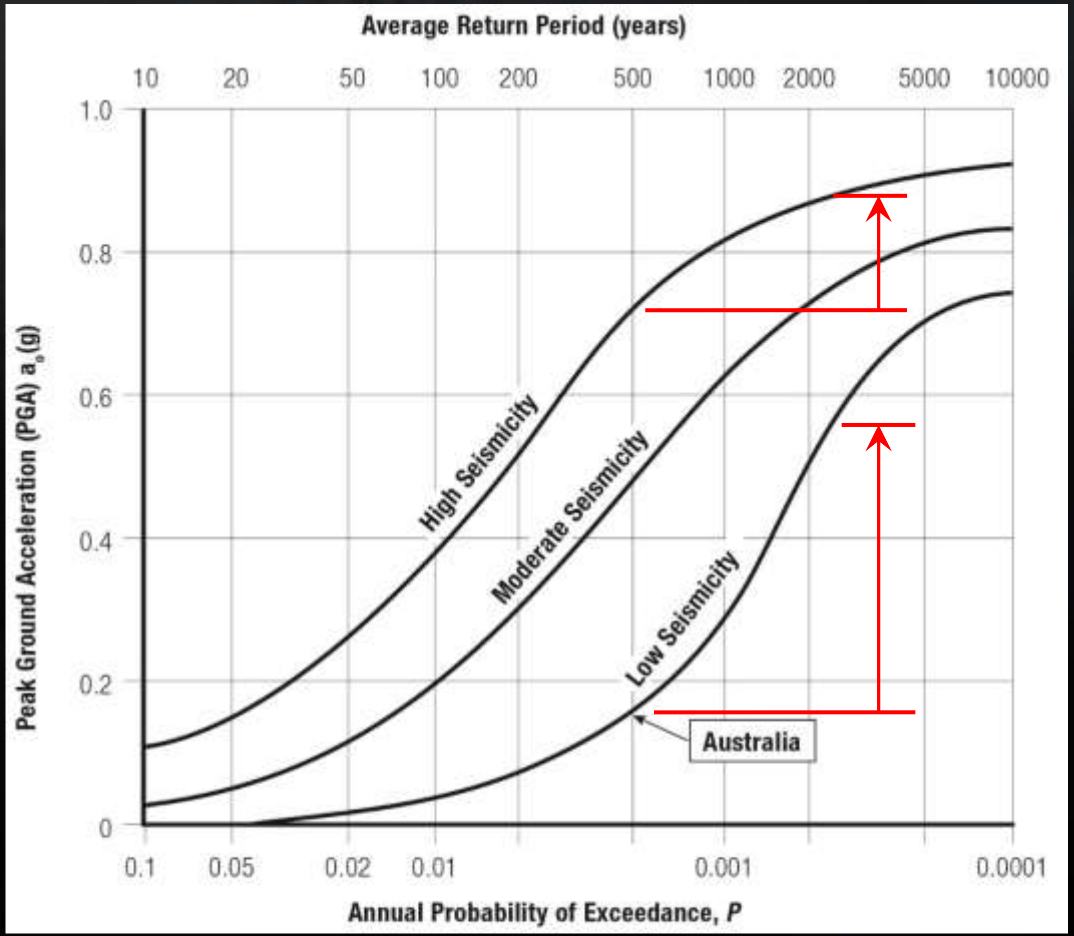
Seismic risk in Australia is considered to be low-moderate (btm curve in graph)

1:500 cf 1:2,500 event – PROBLEM is peak ground acceleration nearly 4 times greater for Australia

1:2,500 - Most buildings would not survive

Proposed 2500 year design requirement for CBD areas?

Blanket minimum design requirement across Australia?



Australia is a *'low-risk'* but *'high-consequence'* country in terms of earthquake damage ie CBD's

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Why Minimum Reinf. Requirements?

Requirements ensure DUCTILITY of Structural Elements

DUCTILITY allows structure to behave inelastically

- Dead Load
- Live Load
- Wind Load

Designed elastically

- Earthquake Load
(1:500 to 1:2,500 years)

Designed:

Elastically for nominal static load

Inelastically for remainder of load

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Structural Ductility and Performance Factors

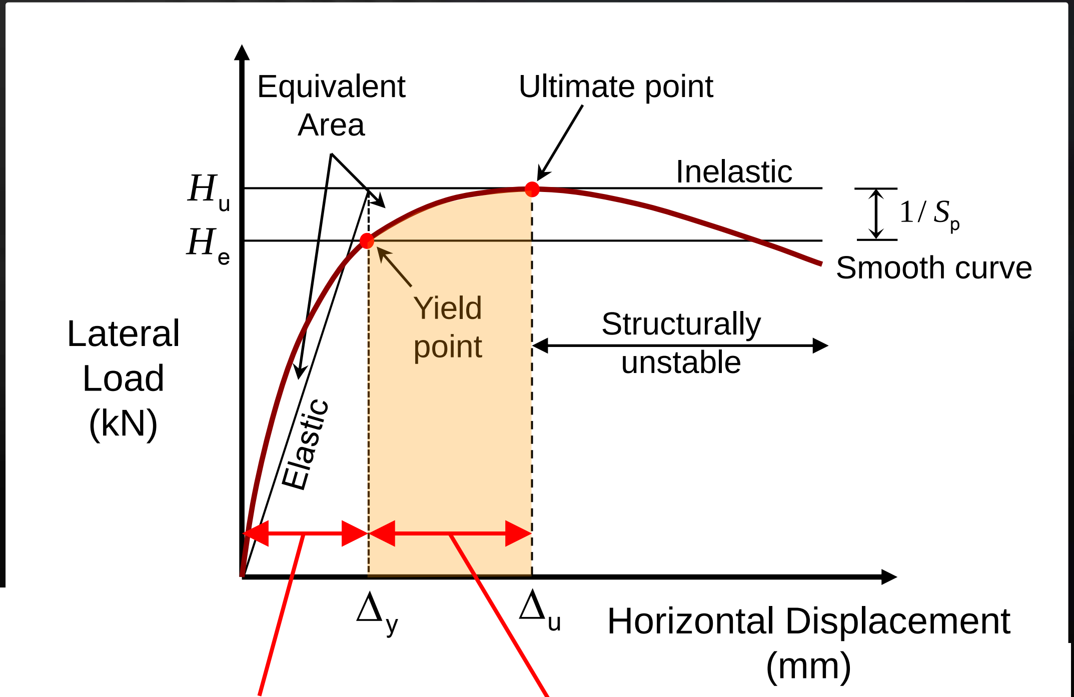
Table 14.3 of AS 3600 (2018) – 4 ductility levels defined for walls

Structural system description	(μ)	S_p	S_p / μ	μ / S_p
Special moment-resisting frames (fully ductile) designed in accordance with NZS 1170.5 and NZS 3101 and the AS 1170.4 Hazard Map	4	0.67	0.17	6
Ductile structural walls designed in accordance with NZS 1170.5 and NZS 3101 and the AS 1170.4 Hazard Map	4	0.67	0.17	6
Ductile partially or fully coupled walls designed in accordance with NZS 1170.5 and NZS 3101 and the AS 1170.4 Hazard Map	4	0.67	0.17	6
Intermediate moment-resisting frames (moderately ductile) designed in accordance with Section 2.2 of this Standard and Clauses 14.4 and 14.5 of this section	3	0.67	0.22	4.5
Combined systems of intermediate moment-resisting frames and moderately ductile structural walls designed in accordance with Section 2.2 of this Standard and Clauses 14.4, 14.5 and 14.7 of this section	3	0.67	0.22	4.5
Moderately ductile structural walls designed in accordance with Section 2.2 of this Standard and Clause 14.4 and 14.7 of this section	3	0.67	0.22	4.5
Ordinary moment-resisting frames designed in accordance with Section 2.2 of this Standard and Clause 14.4 of this section	2	0.77	0.38	2.6
Ordinary moment-resisting frames in combination with limited ductile shear walls designed in accordance with Section 2.2 of this Standard and Clauses 14.4 and 14.6 of this section	2	0.77	0.38	2.6
Limited ductile structural walls designed in accordance with Section 2.2 of this Standard and Clauses 14.4 and 14.6 of this section	2	0.77	0.38	2.6
Non-ductile structural walls designed in accordance with Section 2.2 of this Standard and Clause 14.4 of this section	1	0.77	0.77	1.3

Importance of Ductility

Allows displacement of structure with reduced risk of failure

$$\mu = \frac{\Delta_u}{\Delta_y}$$



From Table 14.3 of AS 3600

Ordinary Moment-resisting frame, $\mu \leq 2$	38% of loading designed for elastically	62% of loading taken inelastically
Intermediate Moment-resisting frame, $2 < \mu \leq 3$	22% of loading designed for elastically	78% of loading taken inelastically

Nominal static load

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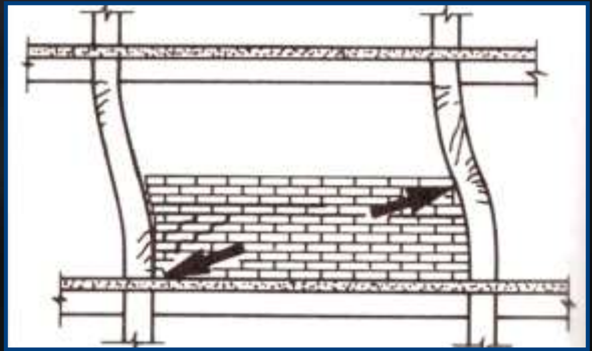
Reinforcement Design & Detailing

Lateral restraint of longitudinal bars – OMRF's

Columns detailed to Clause 14.5 (IMRF) if $L_u \leq 5D$

Need to be more ductile to handle drift over shorter length



Non-structural interaction

- A common failure of this type is the short column shear failure induced by interaction between infill partitions and a reinforced concrete frame.

Short column shear failure
1985 Chilean Earthquake

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Displacement of Structure

Christchurch Art Gallery Bookstore during 2011 earthquake

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Provisions are to ensure Life Safety

Large inelastic displacements can result in significant damage

Christchurch CBD: 90% demolished (over 800 buildings)

Christchurch CBD closed off

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Use of Class N and L reinforcement

The ductility required (μ) determines the Class of reinforcement:

Limited Ductile Walls and OMRFs, $\mu \leq 2$

- Class L can be used as flexural reinforcement in the form of mesh $\phi = 0.64$
- Class L can be used as fitments in the form of rod, bar or mesh
- Class N can be used for both with no restrictions $\phi = 0.8$

Moderately Ductile Walls and IMRFs, $2 < \mu \leq 3$

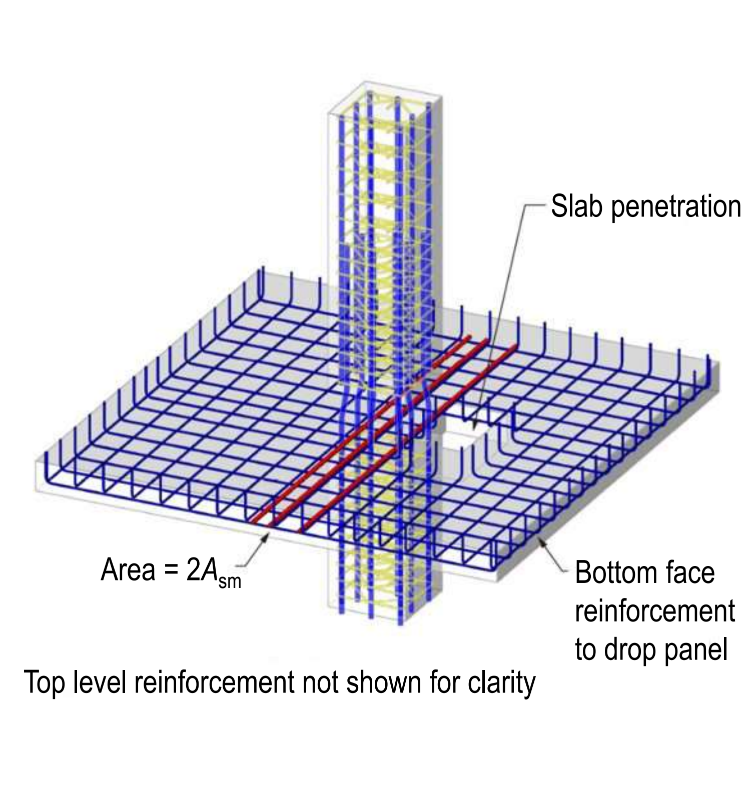
- Only Ductility Class N can be used as ‘flexural’ reinforcement (Clause 14.5.1)
- Ductility Class L is only permitted for fitments and non-flexural reinforcement eg shrinkage and temperature

Detailing of Slabs

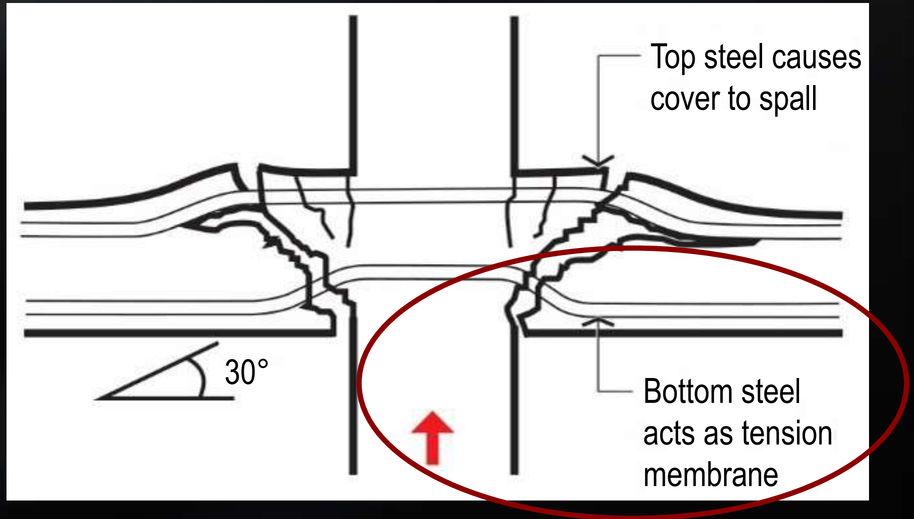
Structural Integrity Reinforcement (AS 3600, Clause 9.2)

Increases resistance of structural system to progressive collapse

Simple Reinforcement Detailing ➡ Improves Life Safety



Common to assess punching shear based on only 3 sides of column



Figures 36 and 37 from SRIA's Seismic Guide

Detailing of Slabs

Structural Integrity Reinforcement – Improves Life Safety

Remains of car park floor – Old Newcastle Workers Club NSW - Brittle failure & progressive collapse
(Photo courtesy Cultural Collections, The University of Newcastle, Australia)

Chapter 14 of AS 3600:2018

Refers to this as continuity reinforcement

Hotel Grand Chancellor
Christchurch, NZ

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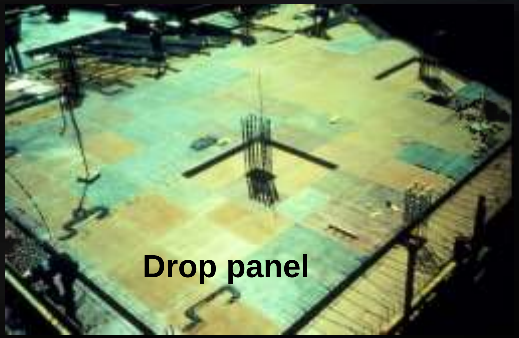
Interpretation of Standard

Clause 9.2.2 Minimum structural integrity reinforcement



The summation of the area of bottom reinforcement connecting the slab, drop panel, or slab band to the column or column capital on all faces of the periphery of a column or column capital shall not be less than,

$$A_{s.min} = \frac{2N^*}{\phi f_{sy}}$$

Integrity reinforcement shall not be required if there are beams containing shear reinforcement and with at least two bottom bars continuous through the joint in all spans framing into the column.

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Interpretation of Standard

- Example – Builder Technical Enquiry

  Builder concerns that a PT slab band arrangement did not have the minimum integrity reinforcement over column

- Some consultants misinterpreting requirements of Clause 9.2.2 by classifying slab band as beam and provision of ‘shear reinforcement’ and two bars passing over column (N12 in this case) as adequate structure integrity reinforcement.

No bottom bars passing over column. Therefore, **NO** structural integrity reinforcement provided

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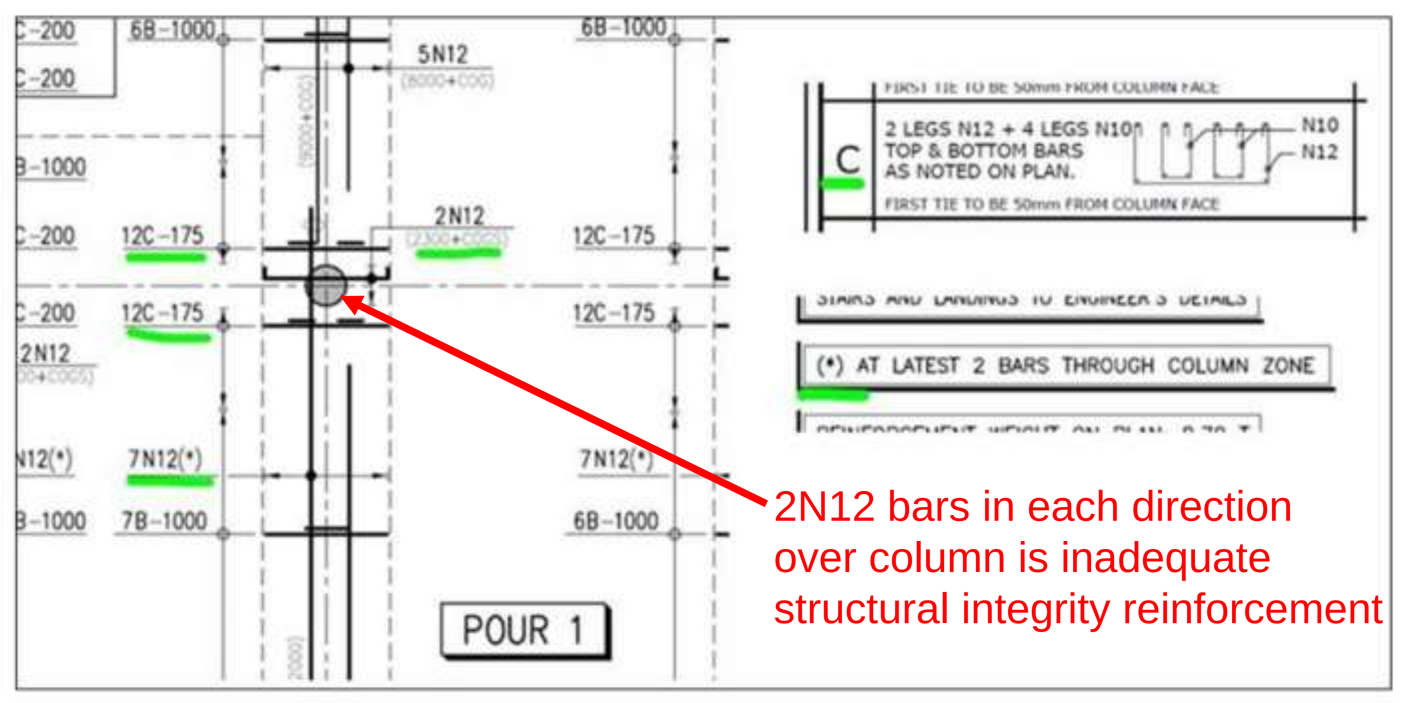
Detailing of Slabs

Technical Enquiry – Post-tensioned slab detailing

Clause 9.2.2 of AS 3600 states that:

“Integrity reinforcement shall not be required if there are beams containing shear reinforcement and with at least two bottom bars continuous through the joint in all spans framing into the column” – Intended for beams and not slab bands

Relates to beam Clause 8.3.1.1 (i) and (ii) – which requires minimum of two bars



Detailing of post-tensioned slab band

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A Failure Mode without Structural Integrity REO

Simple Reinforcement Detailing - Improves Life Safety

Top reinforcement and post-tensioning cables (in top over columns) are ineffective and do not contribute to the punching shear capacity

Remains of post-tensioned car park floor – Christchurch

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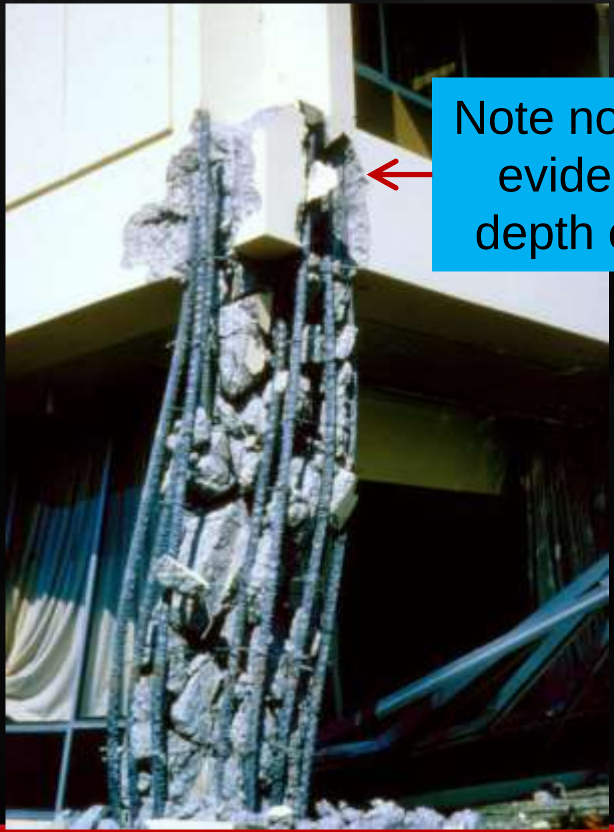
Detailing of Columns

Detailing of reinforcement critical

- Fitments designed not to yield and fail, because
- Once fitments fail, column will generally fail
- Fitments provide confinement and ductility to allow drift of column



Note no fitments evident over depth of beam

Insufficient lateral restraint of column reinforcement

Hotel Grand Chancellor, Christchurch, NZ
(Photograph courtesy Peter McBean)

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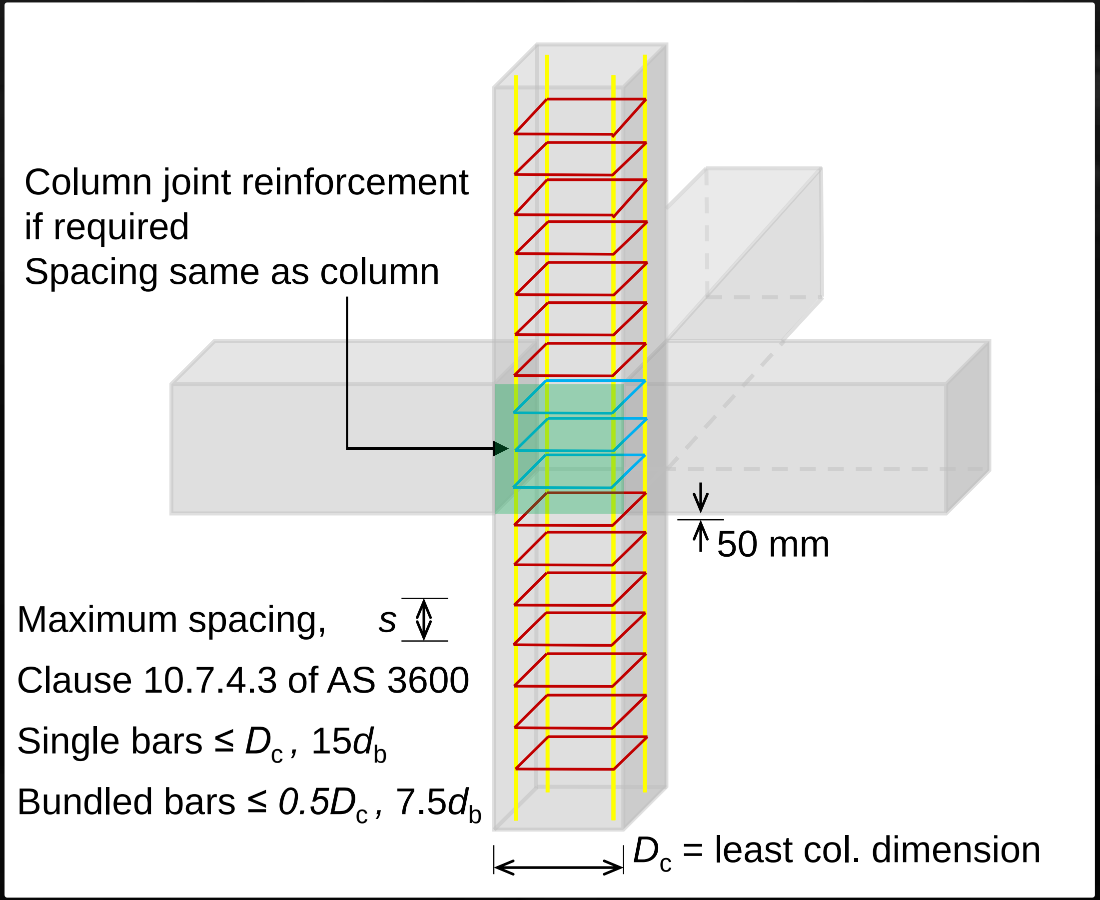
Detailing of Columns

Fitments for Ordinary moment-resisting frames

($f'_c \le 50$ MPa and all load levels)



Size of fitment

Table 10.7.4.3 of AS 3600

Longitudinal bar diameter mm	Minimum bar diameter of fitment and helix mm
Single bars up to 20	6
Single bars 24 to 28	10
Single bars 32 to 36	12
Single bars 40	16
Bundled bars	12

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Detailing of Columns

Beam column joints - Ordinary moment-resisting frames (OMRF's)

Beams on all four sides

No requirement for column joint reinforcement

Beams not on all four sides

Joint reinforcement required

Failure of column at junction with perimeter beam

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Detailing of Columns

Lateral restraint of longitudinal bars – OMRF's

- Single longitudinal bars
  Spacing > 150 mm – all bars
  < 150 mm – every alternate bar
- Bundled longitudinal bars – each bundle

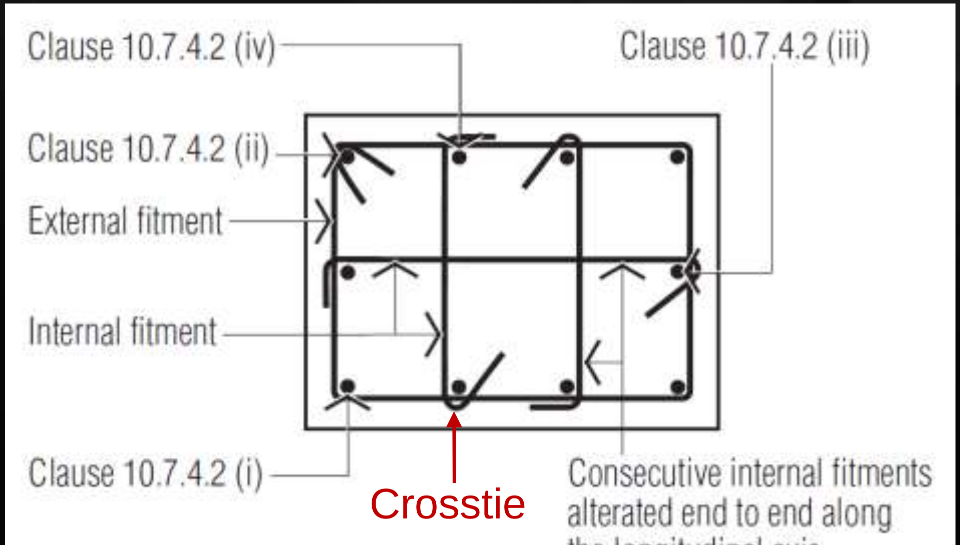

Figure 10.7.4.2 of AS 3600

AS 3600 allows internal fitments with 90° cog only for OMRFs


Cogs must be alternated

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Drift Compatibility

Consider drift and associated displacement compatibility issues

Report into failure of car park by Dames & Moore concluded that:
"Horizontal floor displacements were far in excess of what non-ductile gravity columns could have withstood"

California State University car park collapse, Northridge 1994

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Drift Compatibility

Interior "gravity" frame with conventional detailing failed due to incompatibility with drift capacity of ductile perimeter moment frame.

California State University car park collapse, Northridge 1994

Lesson:
Use detailing consistent with drift demand throughout

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Detailing of IMRF Columns

Minimum Reinforcement Details

Note:

- Maximum fitment spacing (similar to beams)

  Clauses 10.7.3 and 10.7.4

  Clause 14.5.2.2 (b) (c) (d)

  $0.25d_o,\ 8d_b,\ 24d_f$ or 300

  Clause 14.5.4 (a) to (d)

  $0.5D_c,\ 8d_b,\ 24d_f$ or 300

- Closed fitments required over length D
- Crossties require seismic hook at both ends

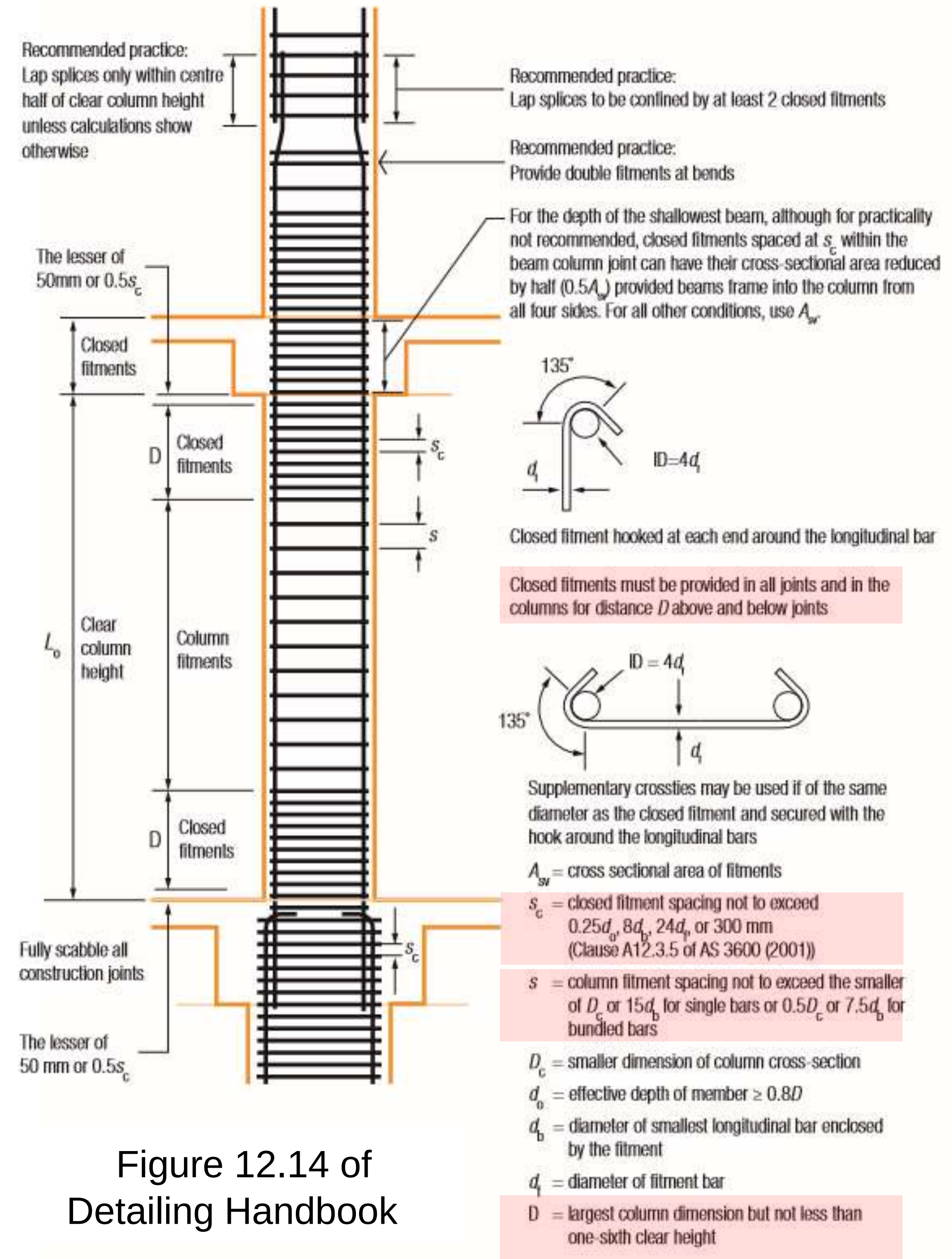

Figure 12.14 of Detailing Handbook

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Detailing of IMRF Columns

Strong column / weak beam design

- Clause 14.5.6 of AS 3600 (2018)
- Requires $\sum M_{\text{nc}} > (6/5)\sum M_{\text{nb}}$
- Only if columns are part of a moment-resisting frame system

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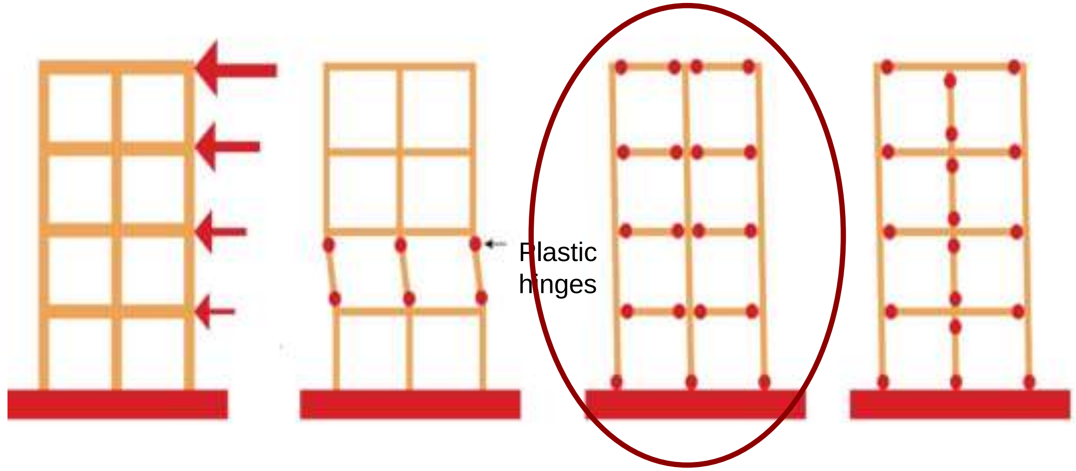
Why Strong Column/Weak Beam?

To promote preferred sidesway mechanism



Frame	(a) Column sidesway mechanism	(b) Beam sidesway mechanism	(c) Mixed sidesway mechanism
	- soft storey (strong beam and weak column) - non-preferred arrangement	- Plastic hinges in beams only (weak beam and strong column) - preferred arrangement	- Interior columns form plastic hinges - Acceptable with adequate design and detailing for ductility

Plastic hinge in beam

Figure 19 — Column, beam and mixed sidesway mechanisms

(after Goldsworthy)

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Detailing of IMRF Columns

Strong column / weak beam concept – Clause 14.5.6 of AS 3600 (2018)

- If impossible to achieve in IMRF (eg wide slab band arrangements)
- Provide alternate lateral support system (eg shear walls or core walls)
- Must design columns for drift induced moments arising from frame action

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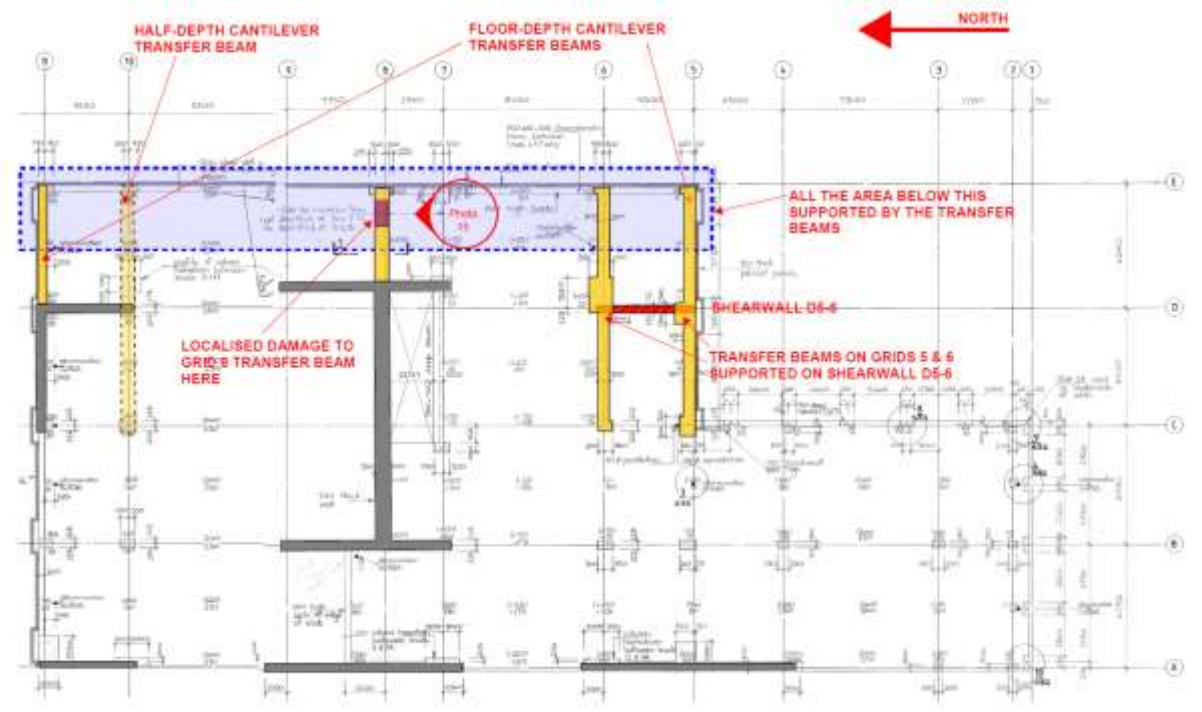
Detailing of Walls

Heavily loaded walls and columns exhibit lower ductility



Failure of shear wall D5-6
Hotel Grand Chancellor, Christcurch, NZ

(Images courtesy Dunning Thornton Consultants Ltd)

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Detailing of Walls

Ensure wall boundary elements (IMRF) are adequately detailed

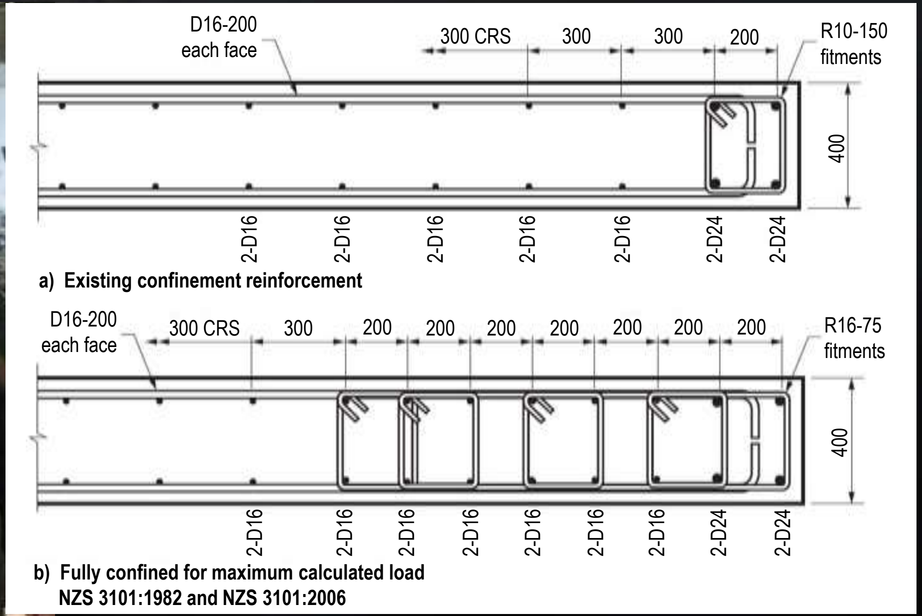

Figure 29 in Guide to Seismic Design

Failure of shear wall D5-6
Hotel Grand Chancellor, Christcurch, NZ

(Images courtesy Dunning Thornton Consultants Ltd)

Figure 28 in Guide to Seismic Design

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Detailing of Walls

Boundary elements required for limited and moderate ductile walls if:

- Vertical reinforcement is not laterally restrained in accordance with Clause 10.7.4, and
- Extreme fibre compressive stress $> 0.15\, f_c'$

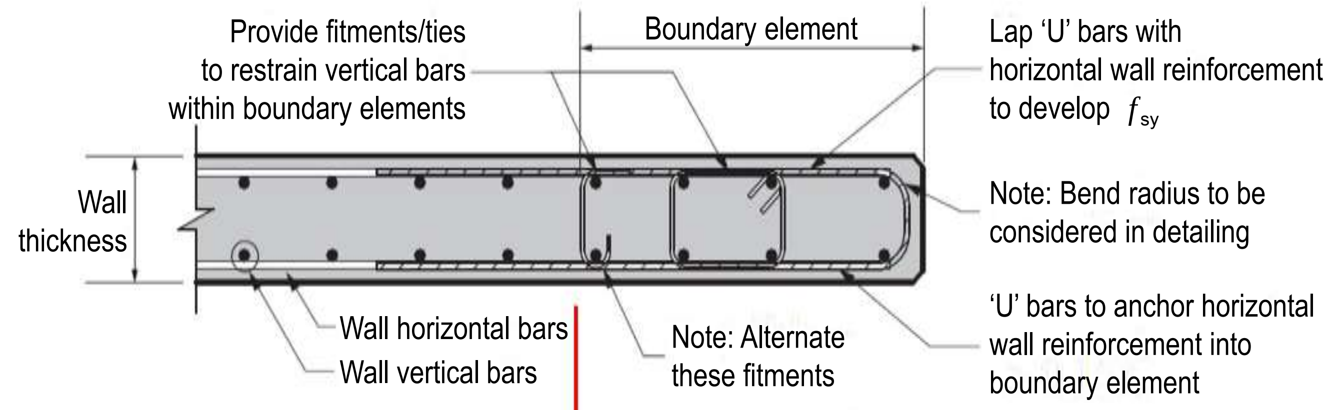

Figure 27 in Guide to Seismic Design

Compressive stress $> 0.15\, f_{sy}'$

If extreme fibre compressive stress $> 0.2\, f_c'$ or $f_c' > 50$ MPa

Detail fitments as for an column – Clause 14.5.4

$(0.5 D_c,\ 8 d_b,\ 24 d_f \text{ or } 300)$

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Detailing of Walls

Columns as Boundary Elements

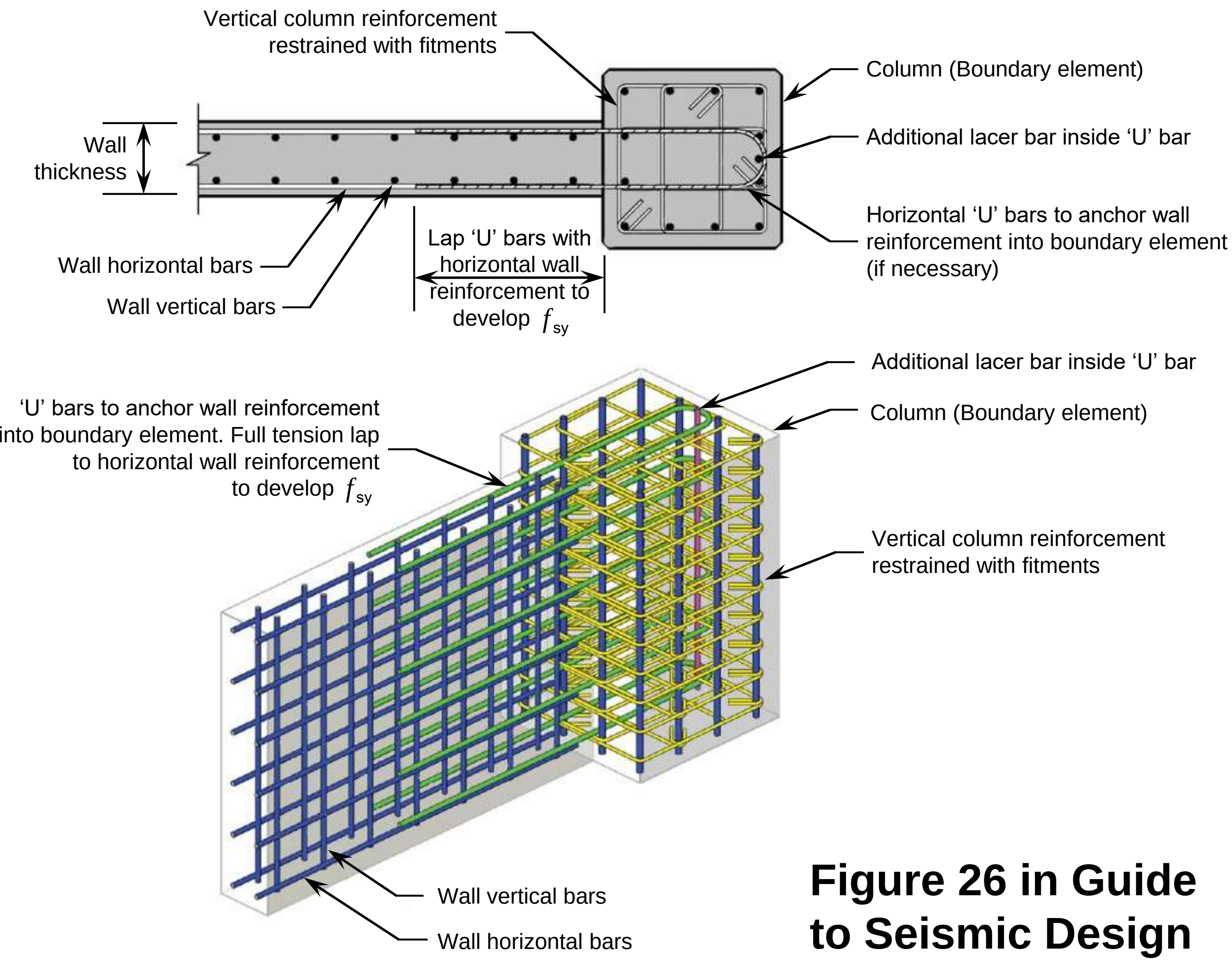

Figure 26 in Guide to Seismic Design

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Detailing of Beams in OMRF's

'Loose bar' detailing allows assembly of prefabricated elements

Satisfactory for ordinary moment-resisting frames (OMRF)

Allows placement of bars at joints

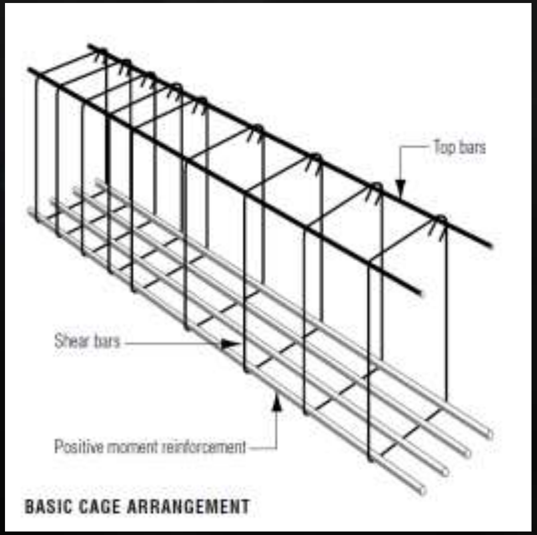

Figure 13.8 Reinforcement Detailing Handbook

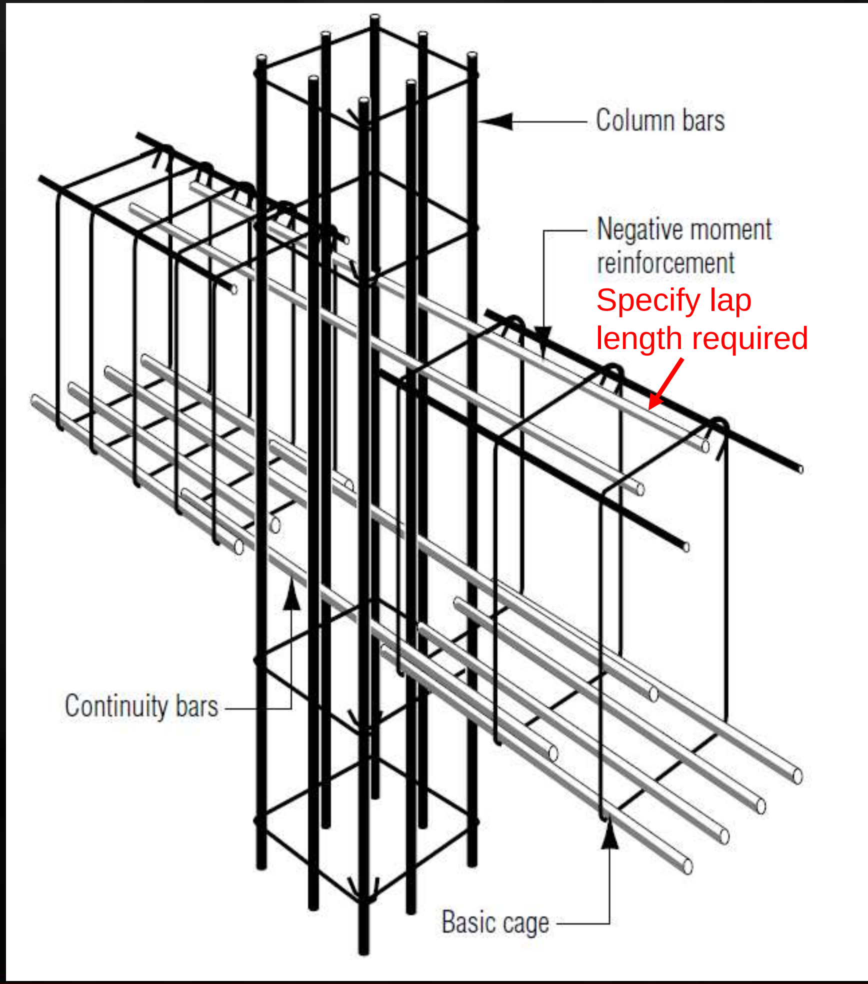

Figure 13.8 Reinforcement Detailing Handbook

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Detailing of Beams in IMRF's

Minimum Splice and Fitment requirements for IMRF

S1 Region

Fitment spacing

Clause 14.5.2.2

Max. $\leq 0.25d_o$

$8d_b$

$24d_f$

300 mm

S2 Region

Fitment spacing

Max. $\leq 0.5D$

300 mm

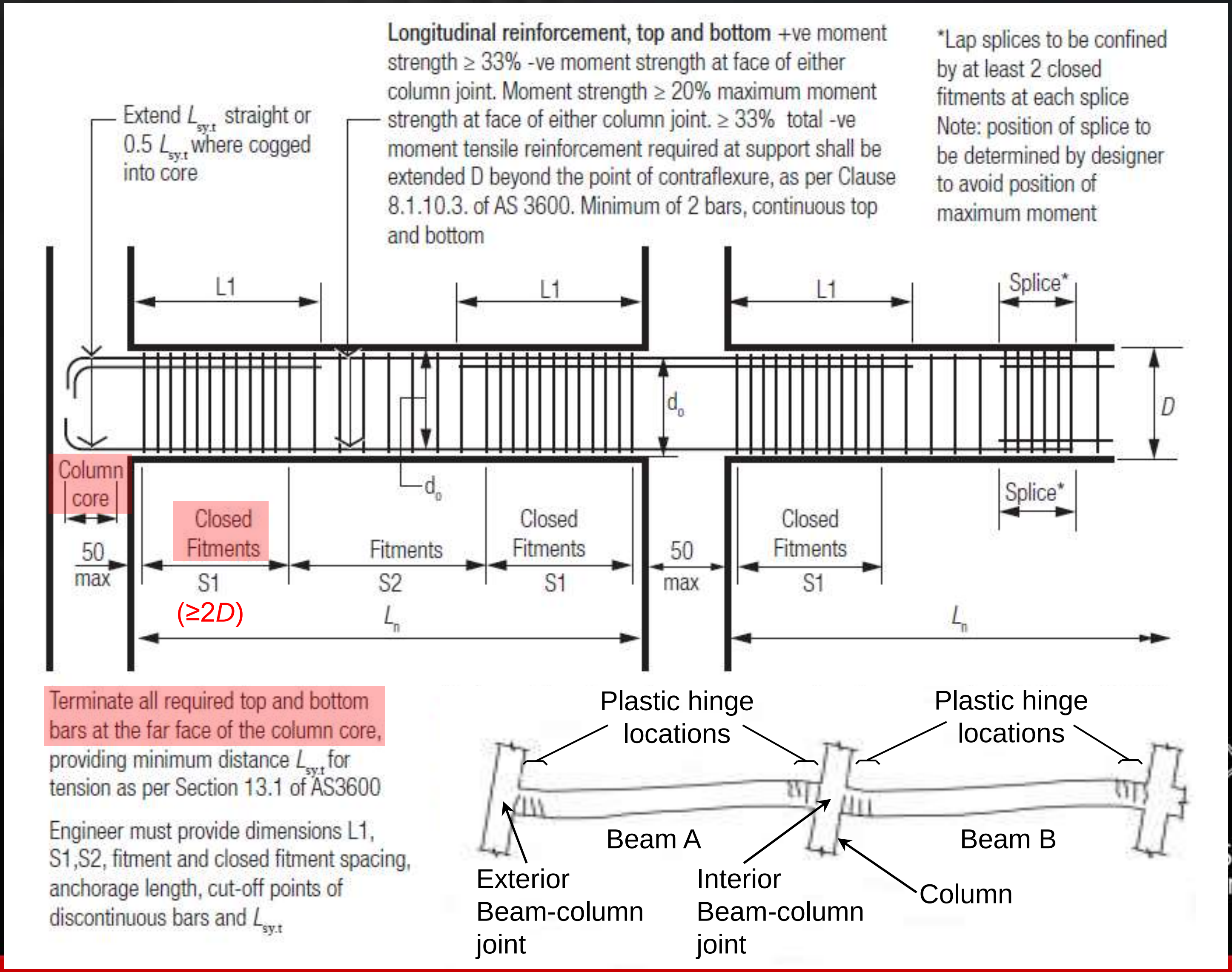

Figure 13.10 Reinforcement Detailing Handbook

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Closed Fitments

Clause 1.6.3.11 Closed fitment

External or internal fitment that forms a continuous perimeter around a concrete element with the ends of the fitment anchored into the concrete using a minimum of 135º hooks around a longitudinal bar.

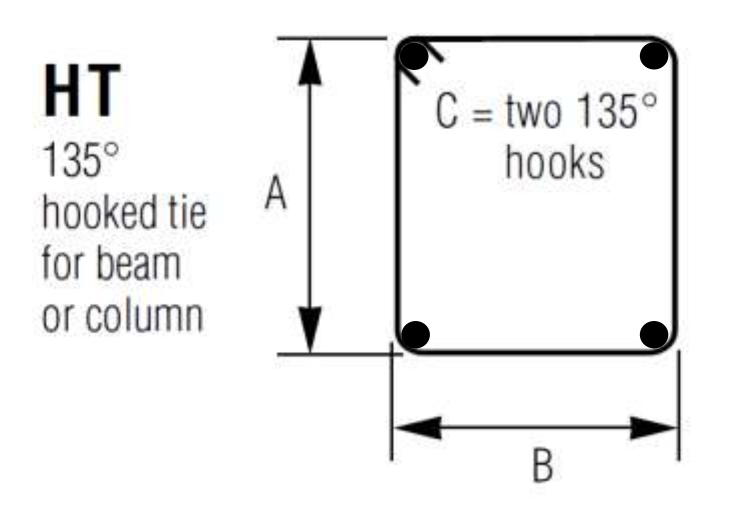

Figure 9.1 from Reinforcement Detailing Handbook
Standardised Bending Shapes for Reinforcement

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Anchorage of Fitments

Clause 8.3.2.4 Anchorage of shear reinforcement

The anchorage of shear reinforcement (fitments) transverse to the longitudinal flexural reinforcement shall be achieved by:

- a hook or cog complying with Clause 13.1.2.7, or
- by welding of the fitment to a longitudinal bar, or
- by a welded splice, or
- by lapped splices (some Engineers allowing this!).

NOTE:

- Site welding not recommended (generally poor quality).
- Difficult achieving sufficient weld to a longitudinal bar.
- Lapped splices (in fitments) intended only for deep infrastructure type beams to allow fabrication.

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Anchorage of Fitments

AS 3600 Commentary Published 25 March 2022

- **Provides additional background information and clarification of Clauses.**

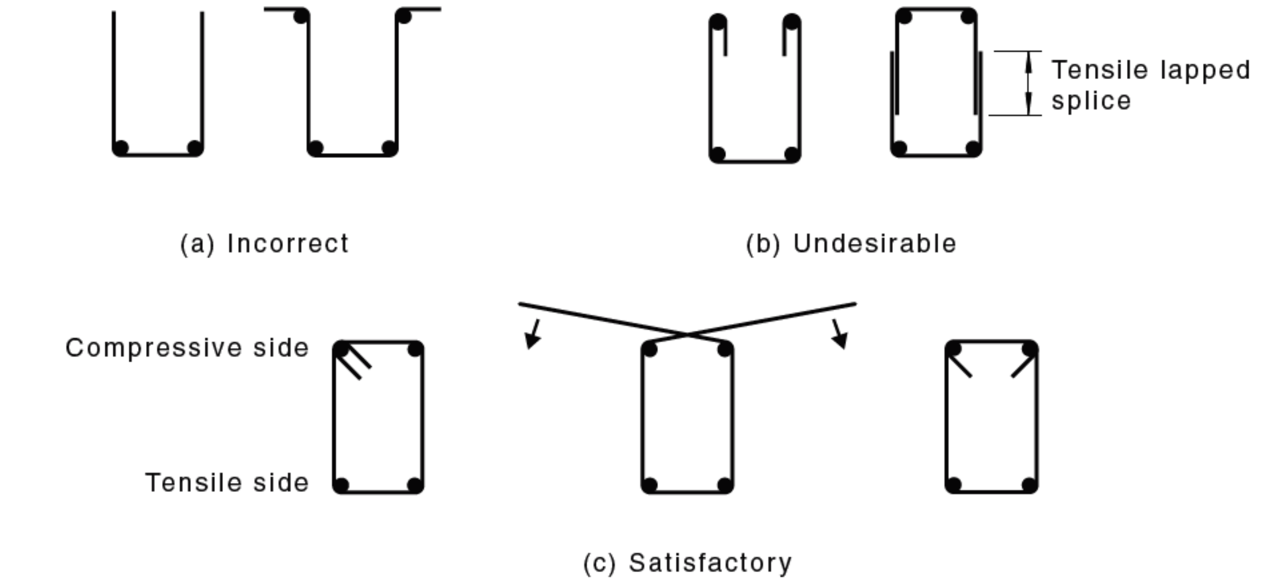

Figure C8.3.2.4(B) — Incorrect, undesirable and satisfactory fitment anchorages (Ref. 37)

Open fitments shown in Figure 8.3.2.4(B)(b) 'do not provide confinement for the concrete in the compression zone and is undesirable in heavily reinforced beams where confinement of the compressive concrete may be required to improve ductility of the member.'

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Detailing of Beams

Anchor beam bars in confined column core

Why? ➡ At about 1.5% drift, the cover concrete will typically be lost

Bottom bars not anchored in the confined region of the column

Failure of a beam column joint at Copthorne Hotel, Christchurch 2011

Images courtesy of Peter McBean Wallbridge and Gilbert

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Design Recommendations

LOAD PATHS

- Use simple, well established, direct load paths that offer predictable behaviour.
- Avoid non-redundant load paths i.e. transfers.

  Consider designing them to remain elastic.

Copthorne Hotel

Images courtesy of Peter McBean, Wallbridge and Gilbert

Crowne Plaza Hotel

Christchurch

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Direct Load Paths

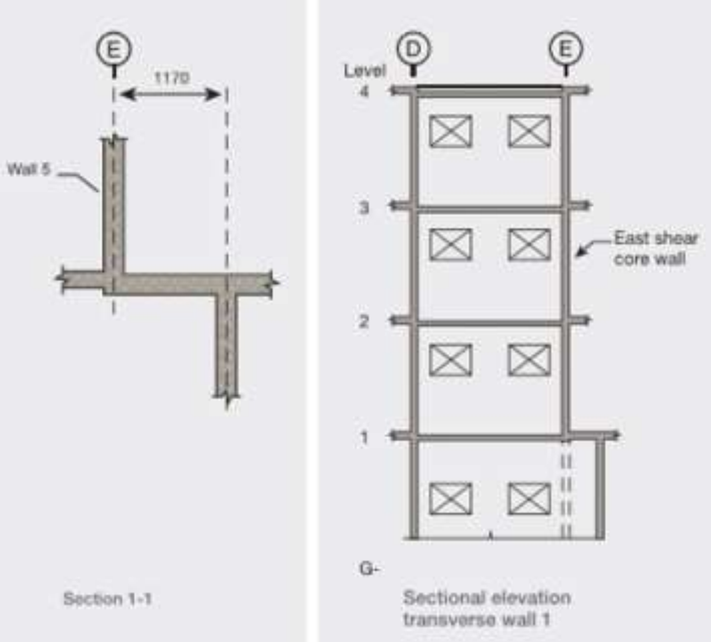
Pyne Gould Building

Poor detailing issues

Lightly reinforced core walls

Poorly restrained columns

Indirect load paths



Images courtesy of Peter McBean, Wallbridge and Gilbert

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SRIA Guides to Assist Designers, Certifiers and Builders

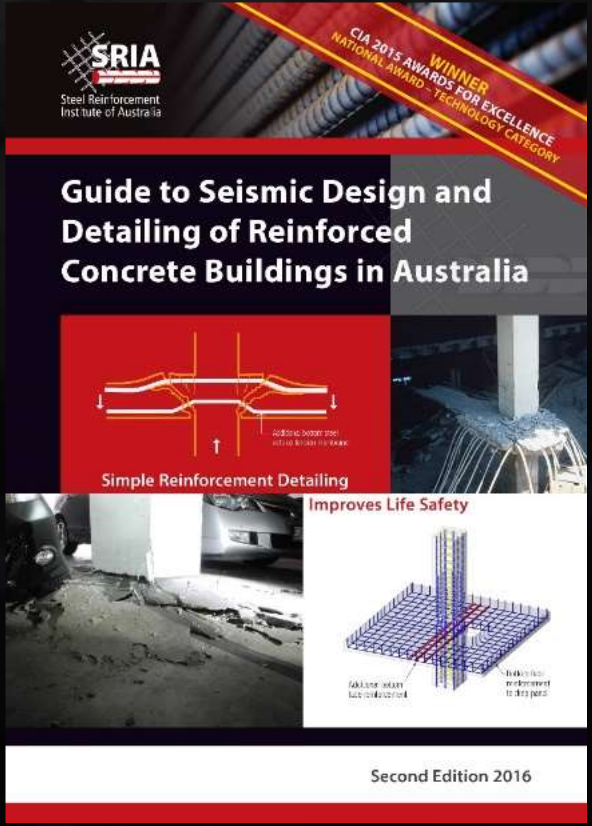
Covers design and detailing requirements for Australia

Good detailing practices covered

Checklists included

Free Pdf download

SRIA.COM.AU



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AS 3600: 2018 - Inclusion of high strength reinforcing steels

NOTE: AS 3600:2018 SUP 1:2022 Published 25 March 2022

AS 3600 1.1.2 *Application*

(d) Higher reinforcing steel grades >500 MPa to 800 MPa meeting the requirements of Table 3.2.1. For ultimate limit states the strength of the reinforcement in design models shall not be taken as greater than 600 MPa unless noted otherwise.

- Notes to Table 3.2.1 **Yield Stress and Ductility of Reinforcement**

NOTES:

1 Reference should be made to AS/NZS 4671 for explanation to designations applying to 500 MPa steels.

2 For higher reinforcing steel grades permitted in Clause 1.1.2(d) the following characteristic properties shall be met:

(a) The following limits for the chemical composition determined by cast analysis shall not be exceeded:

(i) Carbon – 0.33%, Phosphorus – 0.050%, Sulphur – 0.050%.

(ii) The carbon equivalent value shall not exceed 0.49.

(b) The maximum yield strength does not exceed the nominal yield strength by more than 150 MPa.

(c) For steels:

(i) 500 MPa $< f_{sy} \leq$ 700 MPa: uniform elongation $\varepsilon_{su} \geq 0.05$ and the tensile-to-yield stress ratio $R_m/R_e \geq 1.08$.

(ii) 700 MPa $< f_{sy} \leq$ 800 MPa: uniform elongation $\varepsilon_{su} \geq 0.04$ and the tensile-to-yield stress ratio $R_m/R_e \geq 1.04$.

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AS 3600: 2009 & 2018

Inclusion of high strength steels

- Since 2009 Design models have allowed 800 MPa high strength steels ie Clause 10.7.3.3 AS 3600: 2009 (13yrs ago) & continued in 2018
- Core confinement with benefit of reducing congestion

10.7.3.3 *Calculation of core confinement by simplified calculation*

The effective confining pressure applied to the core of a column is calculated as—

$$f_{r.eff} = k_e f_r \qquad \ldots 10.7.3.3(1)$$

where

k_e = an effectiveness factor accounting for the arrangement of the fitments

f_r = average confining pressure on the core cross-section taken at the level of the fitments (see Figure 10.7.3.3)

NOTE: For non-circular sections, f_r is taken as the smaller of the confining pressures calculated for each of the major directions [XX and YY shown in Figure 10.7.3.3(d)].

The average confining pressure on the core at the level of the fitments shall be calculated as follows:

$$f_r = \frac{\sum_{i=1}^{m} A_{b.fit} f_{sy.f} \sin\theta}{d_s s} \qquad \ldots 10.7.3.3(2)$$

where

$A_{b.fit}$ = cross-sectional area of one leg of the fitment

$f_{sy.f}$ = yield stress of the reinforcement used as fitment (not greater than 800 MPa)

θ = angle between the fitment leg and the confinement plane

m = number of fitment legs crossing the confinement plane

d_s = overall dimension measured between centre-lines of the outermost fitments

s = centre to centre spacing of fitments along the column

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AS/NZS 4671: 2019 Steel for the reinforcement of concrete
Scope background

STRENGTH GRADE - BACKGROUND

- Existing Ductility Class L & N grades have not change
- Previous 500 MPa AS/NZS 4671:2001 limit did not allow manufacturers and designers to explore the options of producing higher grades.

  - Can carry higher loads, which in turn may reduce cost
  - Extending limits allows industry to explore the benefits of higher grades of steel
  - Changes are designed to encourage innovation and product development by manufacturers and designers
  - Ultimately benefit to the end user of buildings and structures eg infrastructure
  - Potential to improve the sustainability outcomes for the Australian community

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AS/NZS 4671: 2019 Steel for the reinforcement of concrete
Scope background

NET BENEFIT – STRENGTH GRADE

- High strength steels are typically used internationally for fitments in confinement regions to reduce congestion.
- Research has shown that high strength fitments offer improved performance at the joints of concrete beam/columns under seismic loading and provide:
  - higher load capacity
  - high level of confinement, required to enhance the ductility and strength of the concrete within the core
  - a reduction in steel congestion
  - improved concrete placement
  - savings in the cost of labour
  - reduction in construction time.

Hotel Grand Chancellor, NZ interior column

UNSW & OneSteel paper – Concrete 2019

Strength and Ductility of High-Strength Concrete Columns Confined with High-Strength Steel Ties

Ahsan Parvez[1], Stephen J. Foster[2], Hamid Valipour[3] and Graeme McGregor[4]
[1]Research Associate, School of Civil and Environmental Engineering, UNSW Sydney
[2]Professor and Head, School of Civil and Environmental Engineering, UNSW Sydney
[3]Associate Professor, School of Civil and Environmental Engineering, UNSW Sydney
[4]Manager Technical Development, OneSteel Reinforcing

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AS/NZS 4671: 2019

AS/NZS 4671 – Steel for the reinforcement of concrete

Remains ‘stand alone’

- Aligned closely with
  - ISO 15630, *Steel for the reinforcement and prestressing of concrete, &*
  - ENV 10080, *Steel for the reinforcement of concrete – Weldable reinforcing steel – General*

BUT

- Specific chemical compositions for weldability in prefabrication
- Contains Class E
- Includes higher strength Grades
- Emphasis on long term quality testing
- Incorporates changes proposed by the New Zealand Ministry of Business, Innovation and Employment (MBIE) after the Christchurch 2011 earthquake

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AS/NZS 4671: 2001 cf 2019

Strength Grade:

- 2019 Introduced additional grades of steel, with a lower characteristic yield stress up to 750 MPa.
- Provides the chemical and mechanical requirements for each grade.

AS/NZS 4671 : 2001 cf 2019

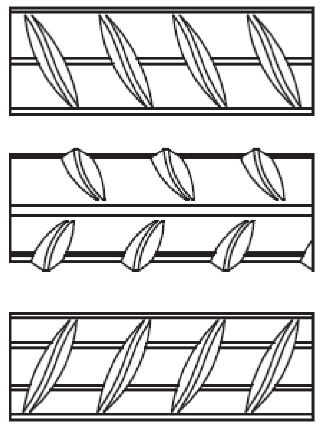
	2001	2019
TITLE	Steel reinforcing materials	Steel for the reinforcement of concrete
STRENGTH (Standard Grades)	≤ 500 MPa 250N, 500N, 300E & 500E	≤ 750N 250N, 500N, 300E & 500E, 600N & 750N
OTHER GRADES	-	Will allow non-standard Grades
QUALITY	LONG TERM QUALITY and BATCH TESTING	LONG TERM QUALITY and BATCH TESTING Introduces TYPE testing
REPORTING	Test Report	Manufacturer's Certificate

InfraBuild (Formerly: Liberty Steel and prior OneSteel)
Test piece from recent UNSW research

> 500 MPa – shall be identified by an alphanumeric marking system on the surface of the bar that identifies strength grade and ductility class at intervals of not greater than 1.5 m.

e.g 750N 9.8 AAA

≤ 500 MPa – shall be identified by either an alphanumeric marking system on the surface of the bar that identifies strength grade and ductility class or by a series of surface features on the product at intervals of not greater than 1.5 m.



Grade 500N

High strength reinforcing > 500 MPa

AS 3600 : 2018

10.7.4.3 *Diameter and spacing of fitments and helices*

1.6.3.42 *Fitment*

Unit of reinforcement commonly used to restrain from buckling the longitudinal reinforcing bars in beams, columns and piles; carry shear, torsion and diagonal tension; act as hangers for longitudinal reinforcement; or provide confinement to the core concrete.

NOTE: Also referred to commonly as a stirrup, ligature or helical reinforcement.

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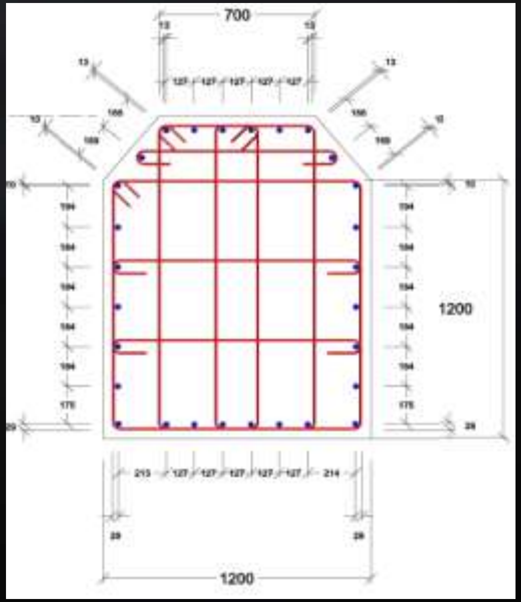
High strength reinforcing > 500 MPa

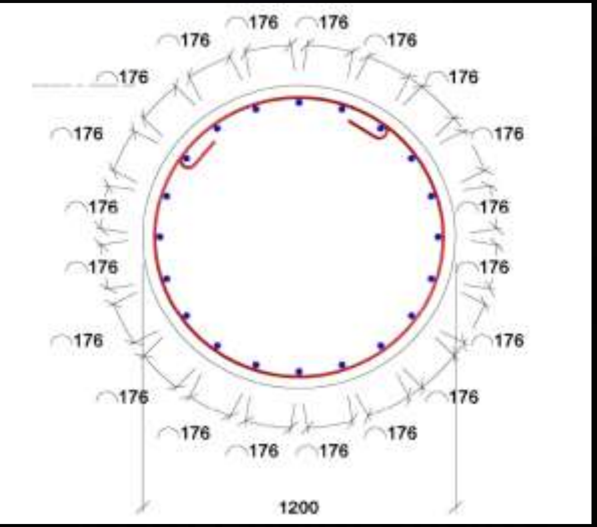
AS 3600 : 2018

10.7.4.3 *Diameter and spacing of fitments and helices*

- "For fitments of strength greater than 500 MPa, the minimum bar diameter of the fitment may be reduced by the factor $\sqrt{500 / f_{sy.f}}$"

	$f_{sy.f}$ (MPa)		
	500	750	MASS REDUCTION
DIAMETER (mm)	10	8.2	33%
	12	9.8	
	16	13.1	





High strength reinforcing > 500 MPa

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Green Building Council Australia

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Can I claim 1 innovation point for using 750 MPa steel fitments of reduced diameter on my project?

Yes, projects may pursue one (1) innovation point through 30A Innovative Technology or Process where the use of 750 MPa steel fitments of a reduced diameter are installed in lieu of equivalent 500 MPa fitments** (also known as ligatures) under the **following conditions**:

- A minimum of 70% of the structural columns for the entire building, by length, are concrete and require steel reinforcement; and
- 95% or more of the fitments used in these columns are ≥750 MPa replacing the equivalent 500 MPa fitments**; and
- 95% or more of the fitments are supplied by a Steel Maker that meets the Responsible Steel Maker requirements in the Responsible Building Materials (20.1) credit; and
- the fitments supplied meet Australian Standard AS 3600-2018 and have a CEV value not exceeding 0.49; and
- is a trademarked product; and
- The project team achieves either
  - One (1) point in the Reduced Use of Steel Reinforcement (Concrete framed building) credit (19B.2B) not including the reduction in mass of fitments; or
  - An improvement of 4% in the Climate Change Impact category of the Life Cycle Assessment credit (19A) across all modules as a whole, excluding the B6 Operational Energy module.

https://www.gbca.org.au/faqs.asp?action=details&faqId=112

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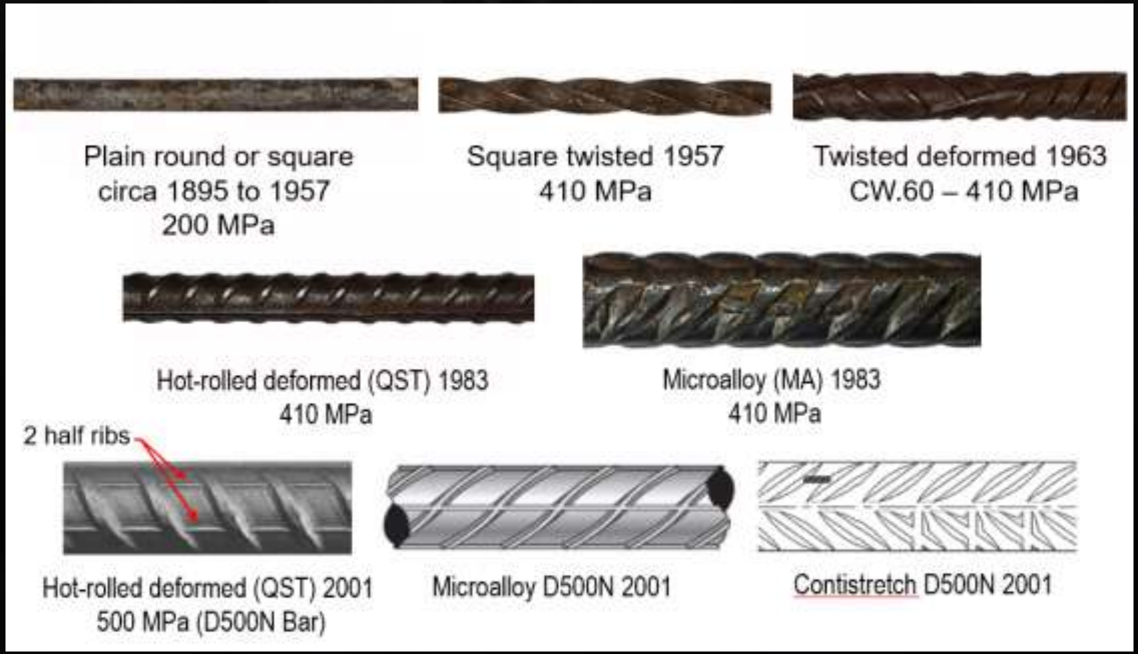
Guide to Historical Steel Reinforcement in Australia

Available to order from web site

Written to address the volume of technical enquiries in this area

Covers reinforcement from 1895 to present time



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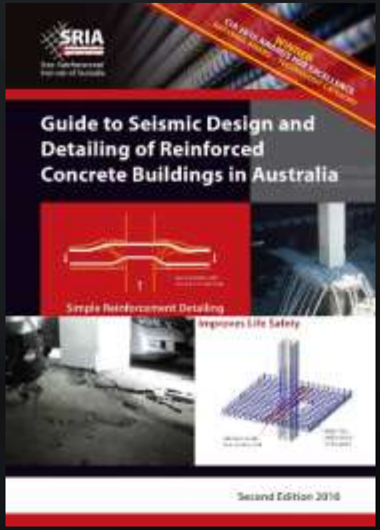
Conclusions

- SRIA is here to assist
- Steel reinforcement is a high technology product
- Be aware of site practices that impact compliance eg overheating/impact
- Quality assurance is essential for every project
- Specify & obtain a JAZ-ANZ accredited 3rd party 'Processor' Certificate
- Check key detailing eg structural integrity reinforcement
- Latest Standard addresses critical issues for life safety
- Prefabricated reinforcement also requires inspection
- Site inspection & certification is the last opportunity to guarantee quality



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Building futures through sustainable steel

AUSREO
Build with confidence

NEUMANN STEEL

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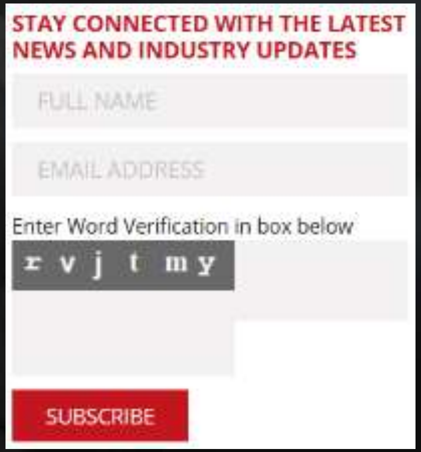

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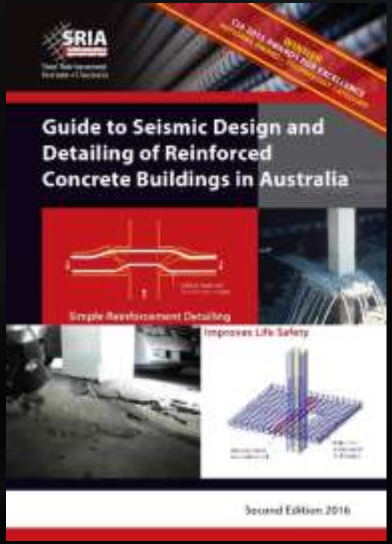

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Thank you

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